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(54) **ITEM IDENTIFYING MOBILE APPARATUS**

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**B62B 5/06** (2006.01)  
**G06Q 30/0601** (2023.01)  
**B62B 3/18** (2006.01)

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See application file for complete search history.

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*Primary Examiner* — James A Shriver, II

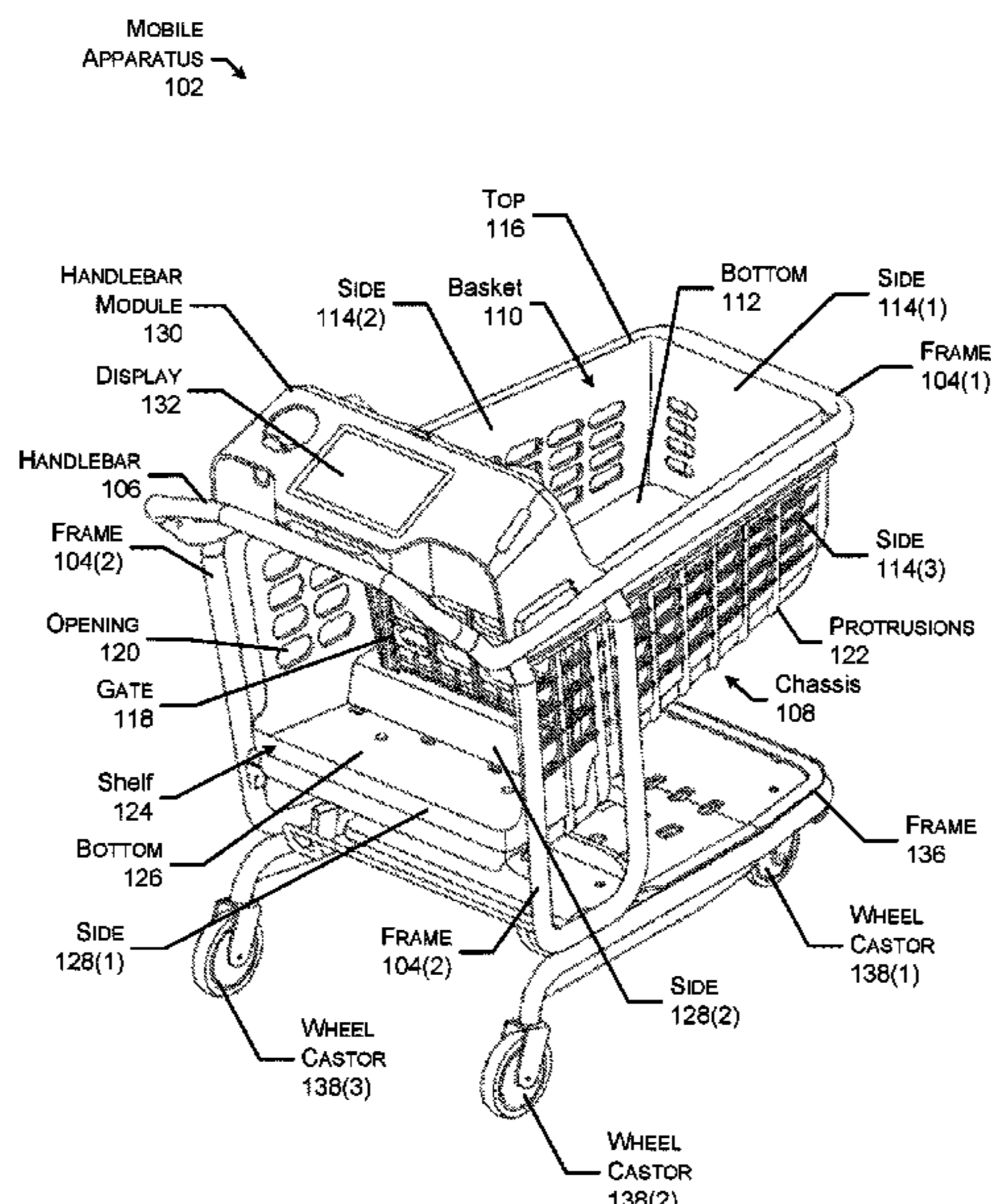
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(57) **ABSTRACT**

This disclosure describes, in part, a mobile apparatus for identifying items. For instance, the mobile apparatus may include a main frame, a chassis attached to the main frame, and a basket that attaches to the chassis in order to prevent the basket from contacting the main frame. One or more sensors, such as weight sensor(s), may be located between the basket and the main frame. The mobile apparatus may further include a shelf that extends substantially horizontally from the main frame, where a gate separates the basket from the shelf. A user may then place first item(s) within a receptacle of the basket and second item(s) within a receptacle of the shelf. The mobile apparatus may further include a handlebar module attached to the main frame, where the handlebar module includes an opening for inserting a removable battery of the mobile apparatus.

**21 Claims, 18 Drawing Sheets**



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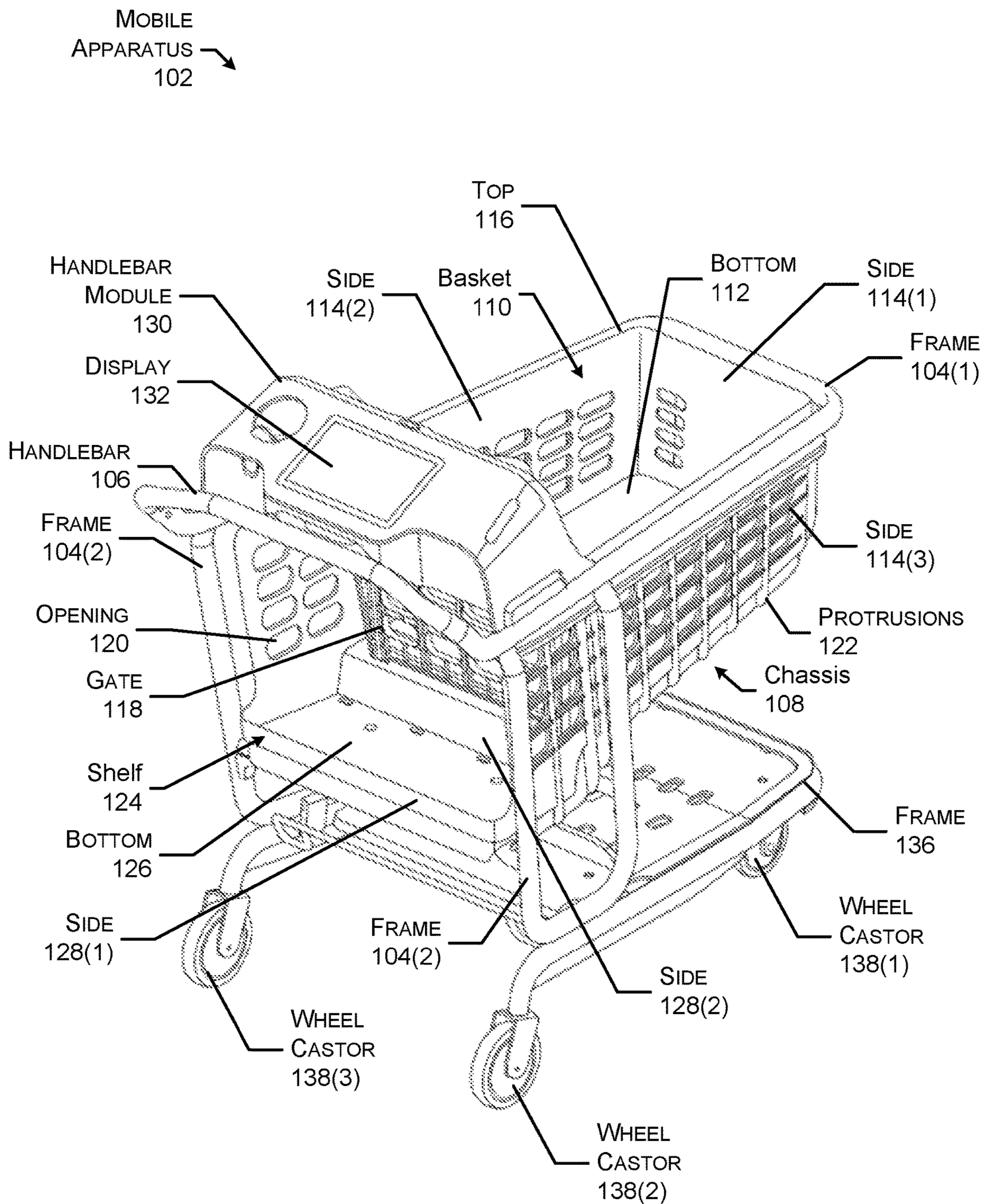


FIG. 1A

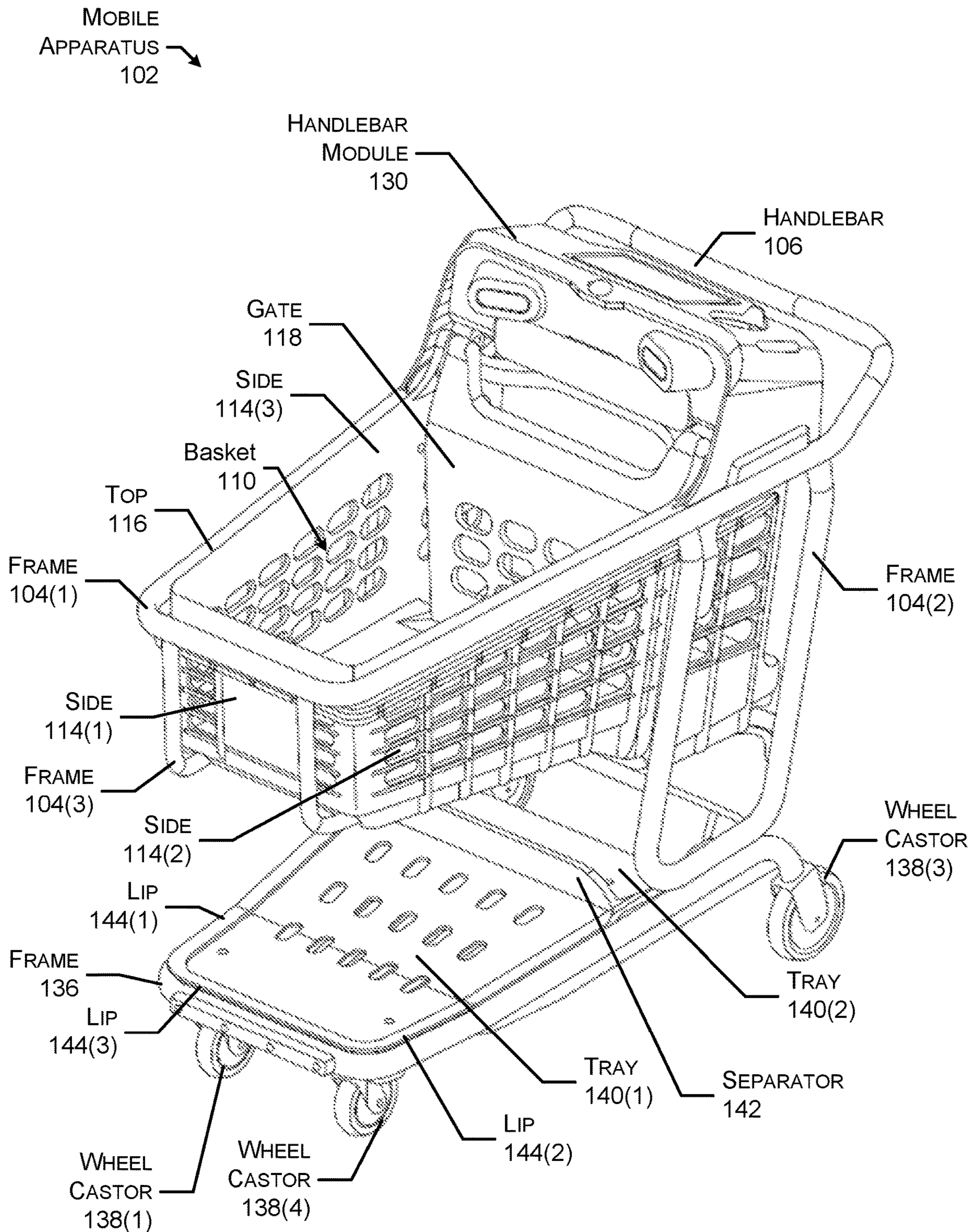


FIG. 1B

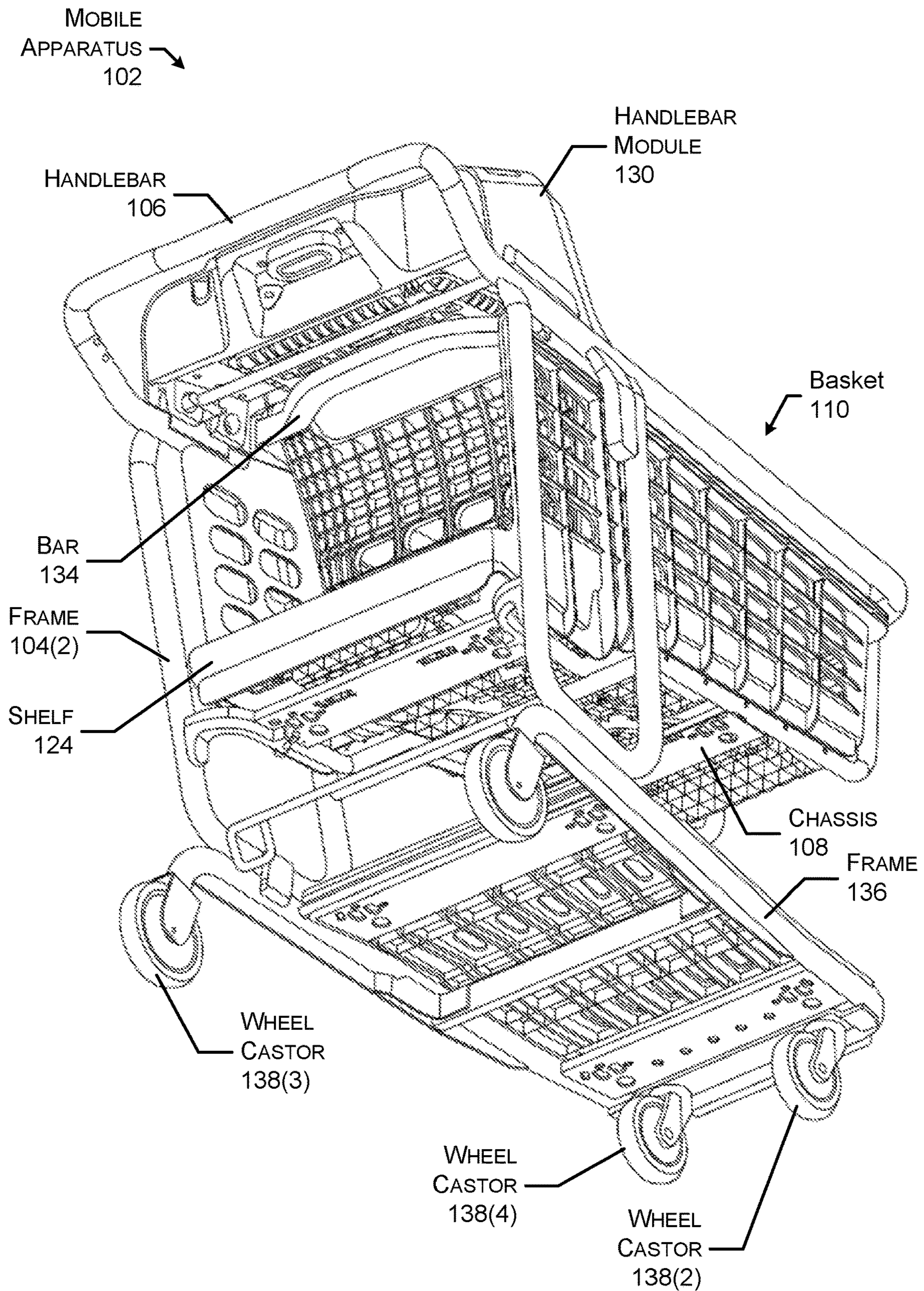


FIG. 1C

MOBILE APPARATUS 102

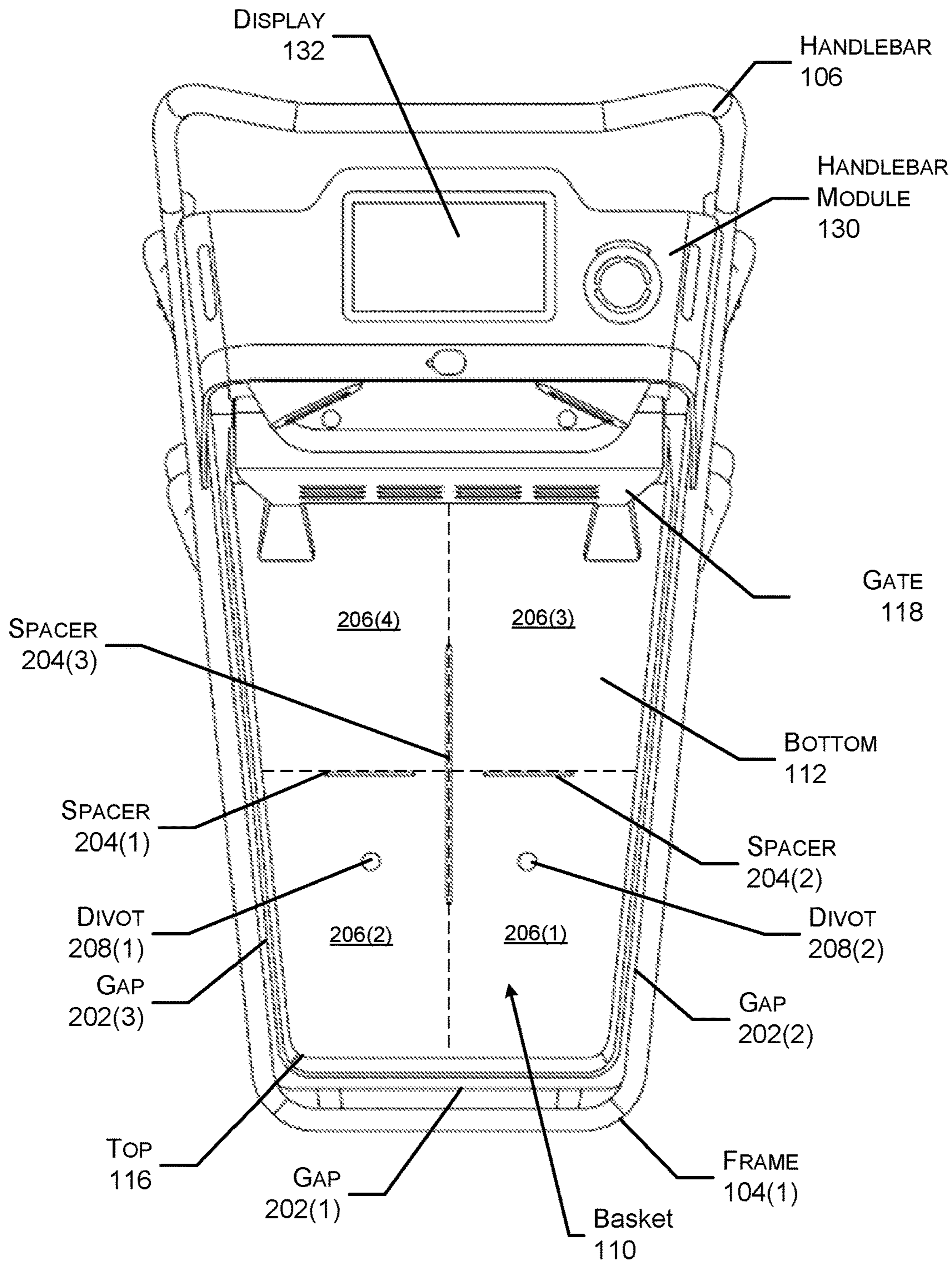


FIG. 2

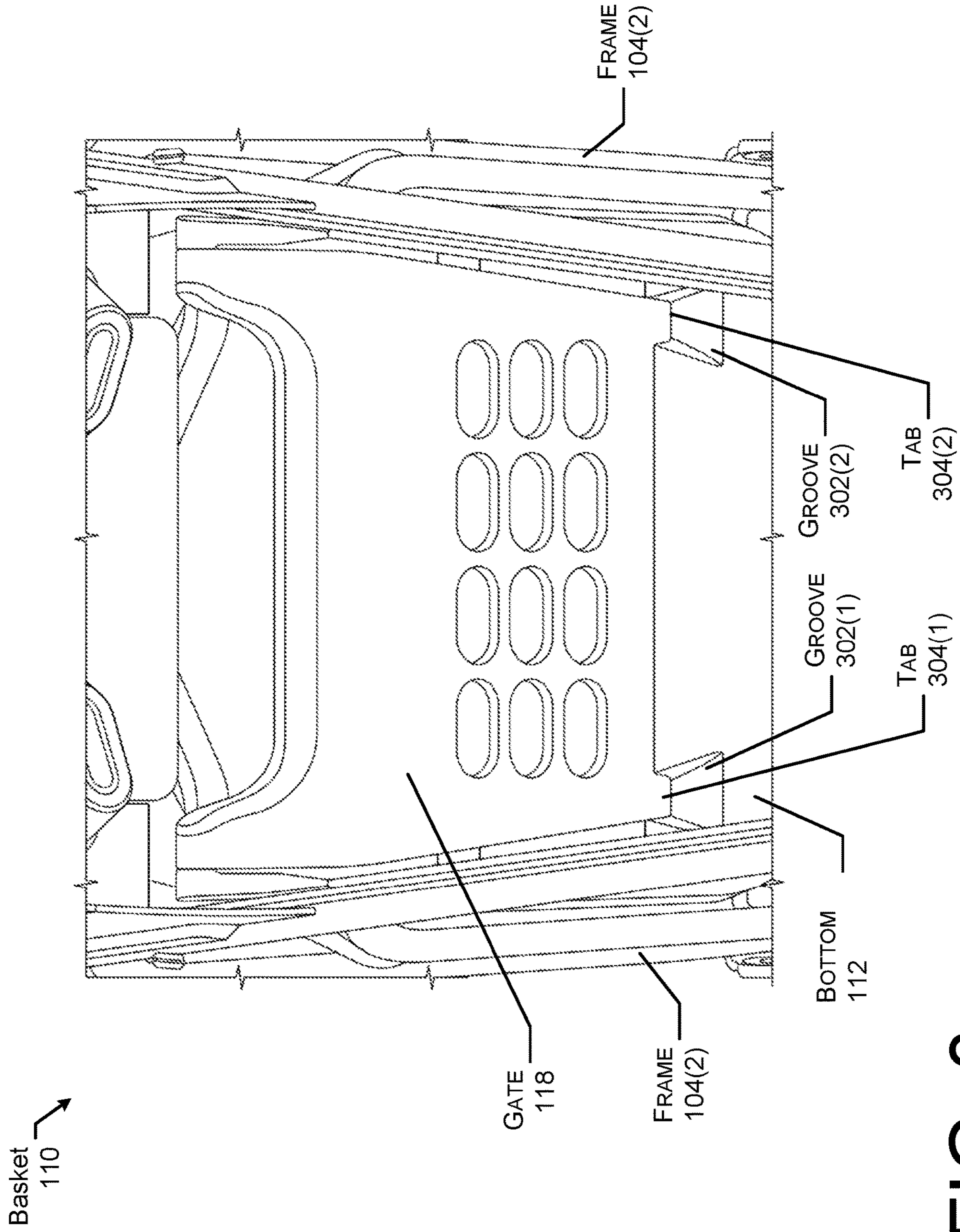


FIG. 3

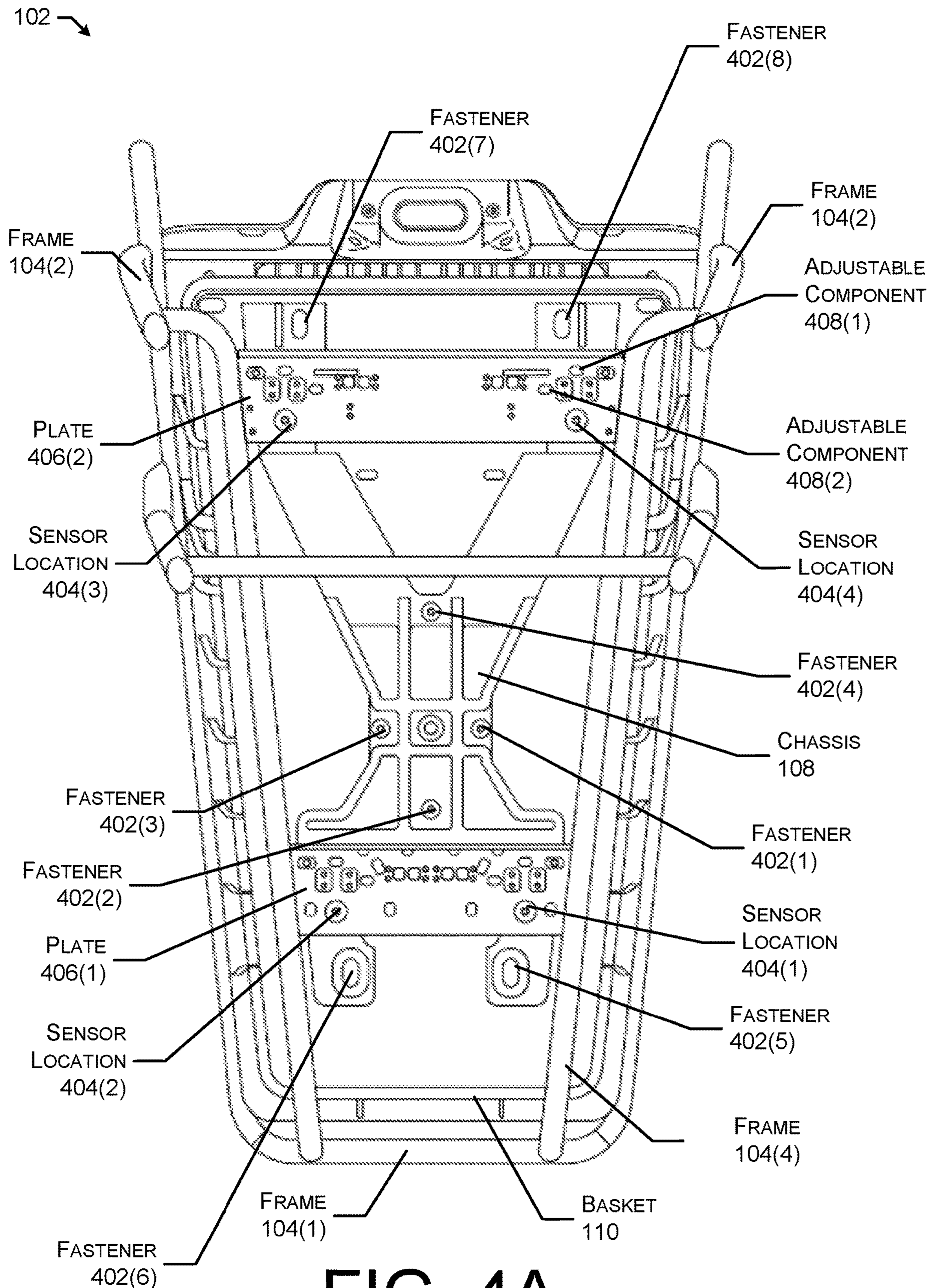


FIG. 4A



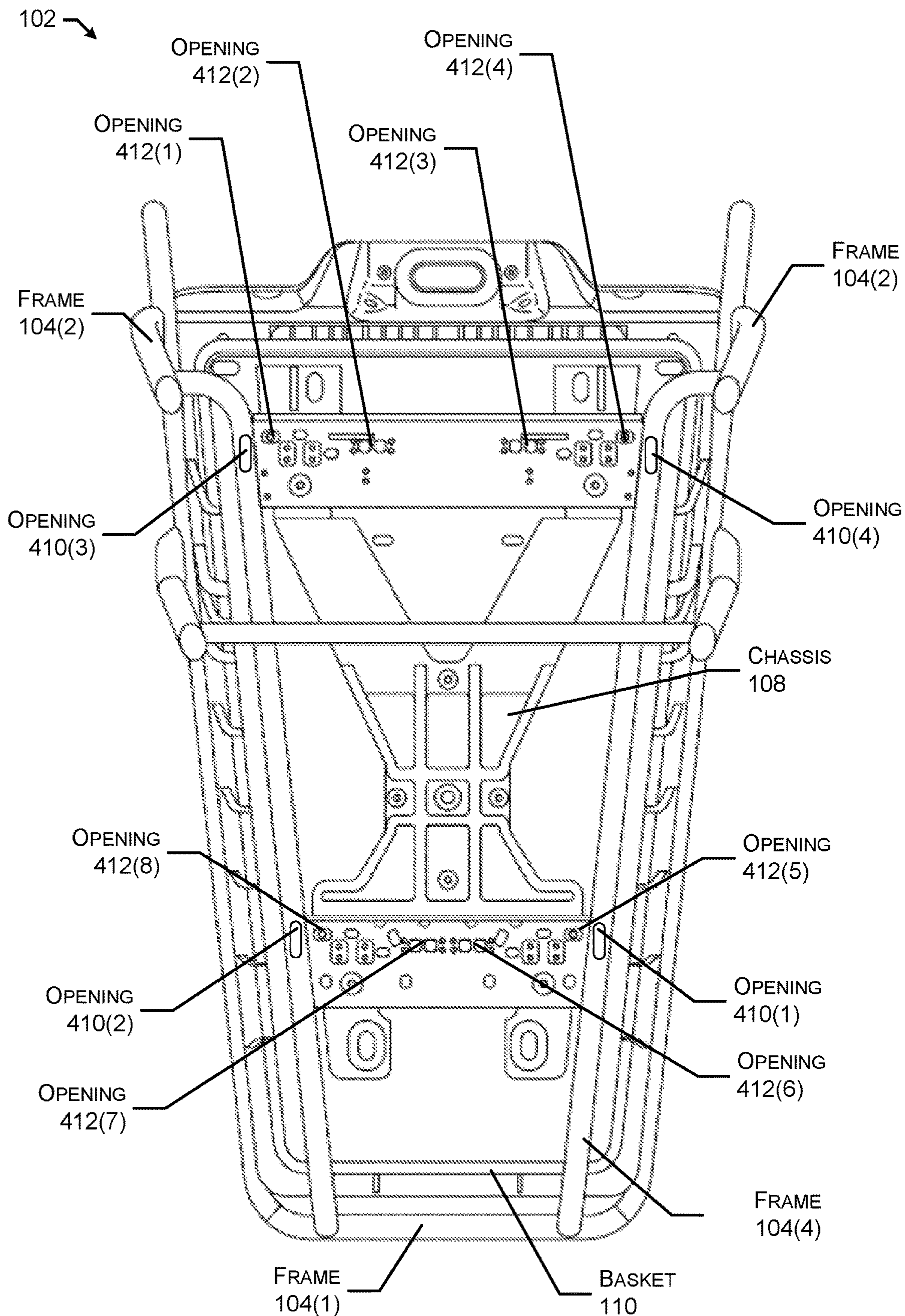


FIG. 4B

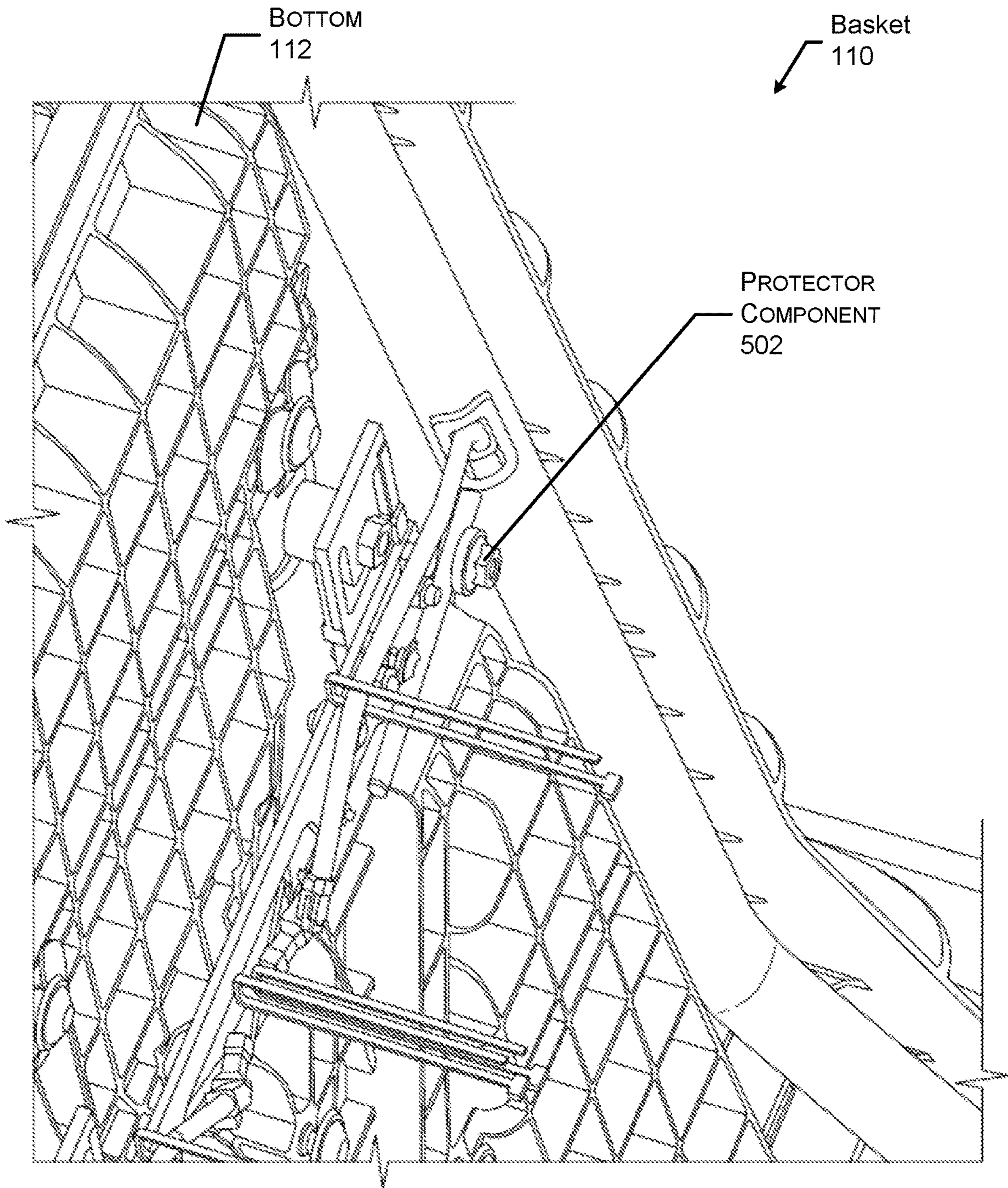


FIG. 5

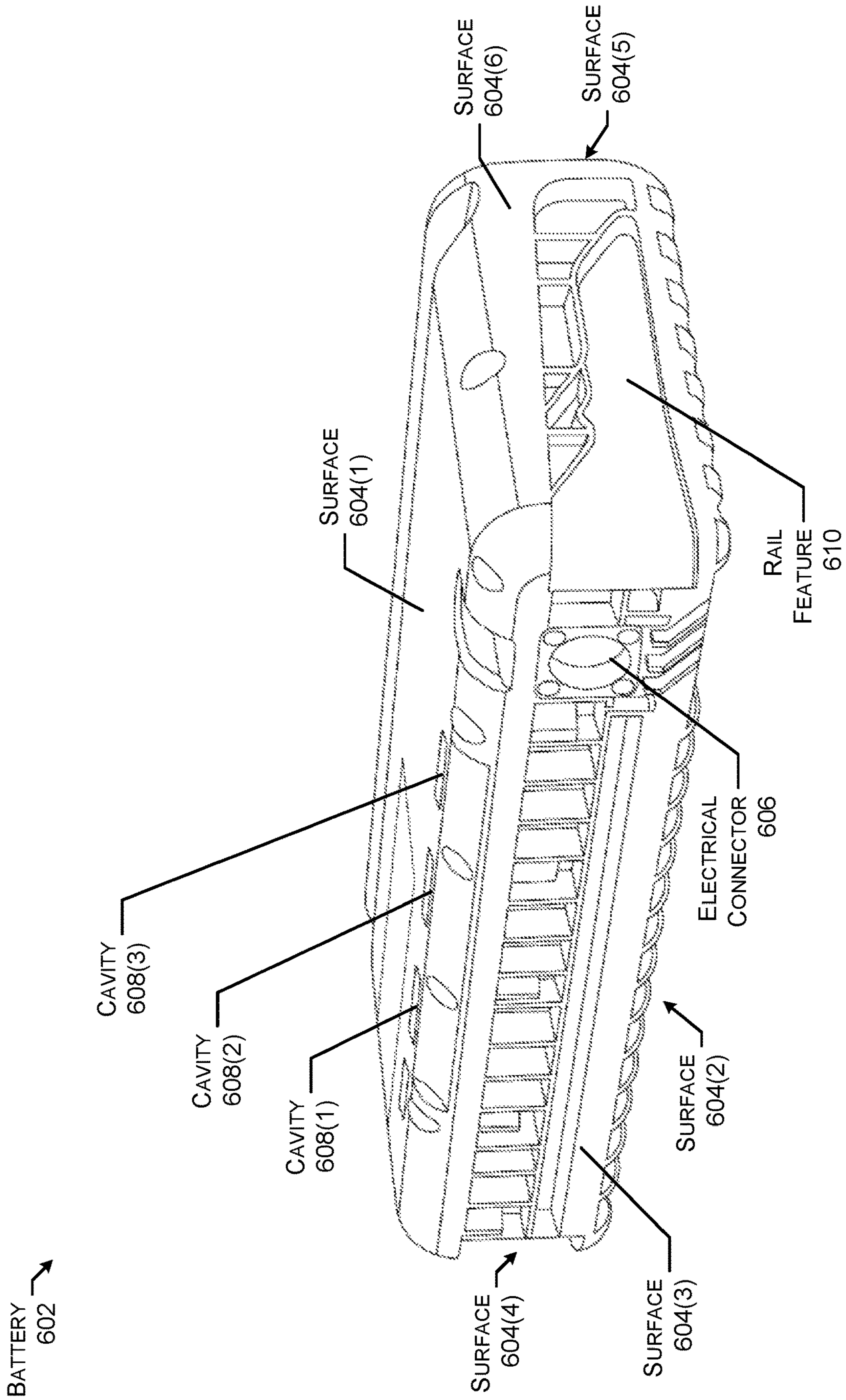


FIG. 6

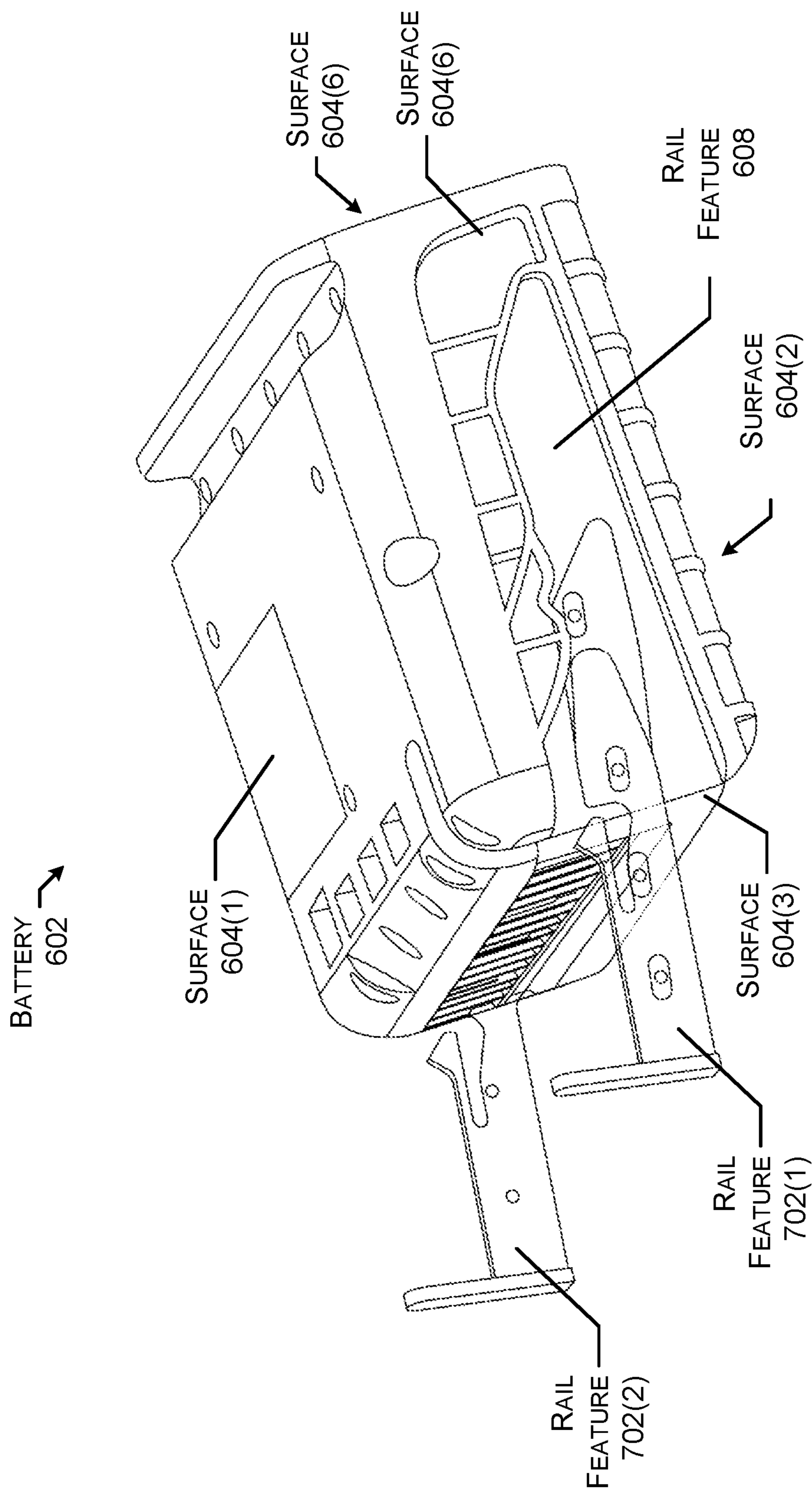


FIG. 7

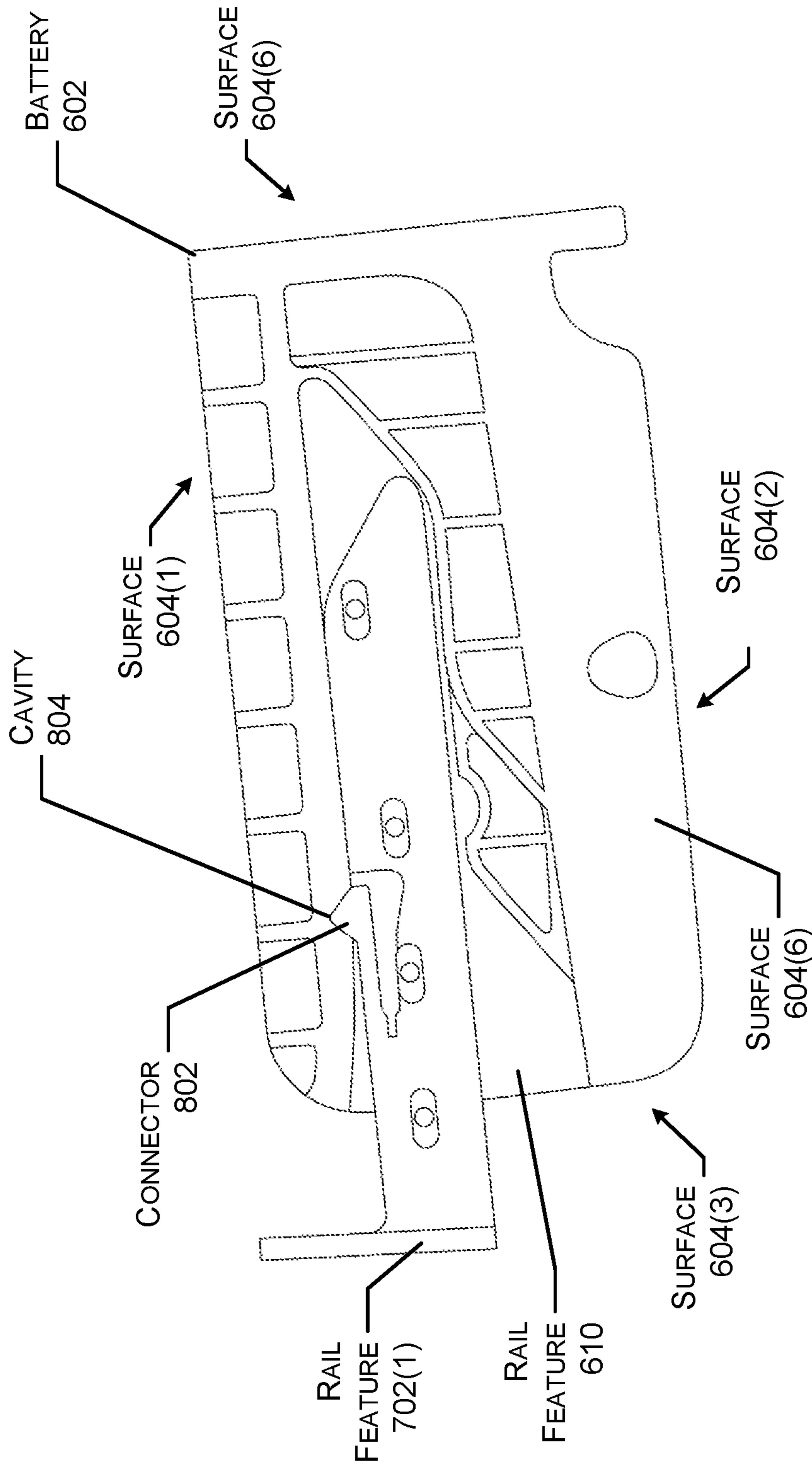


FIG. 8A

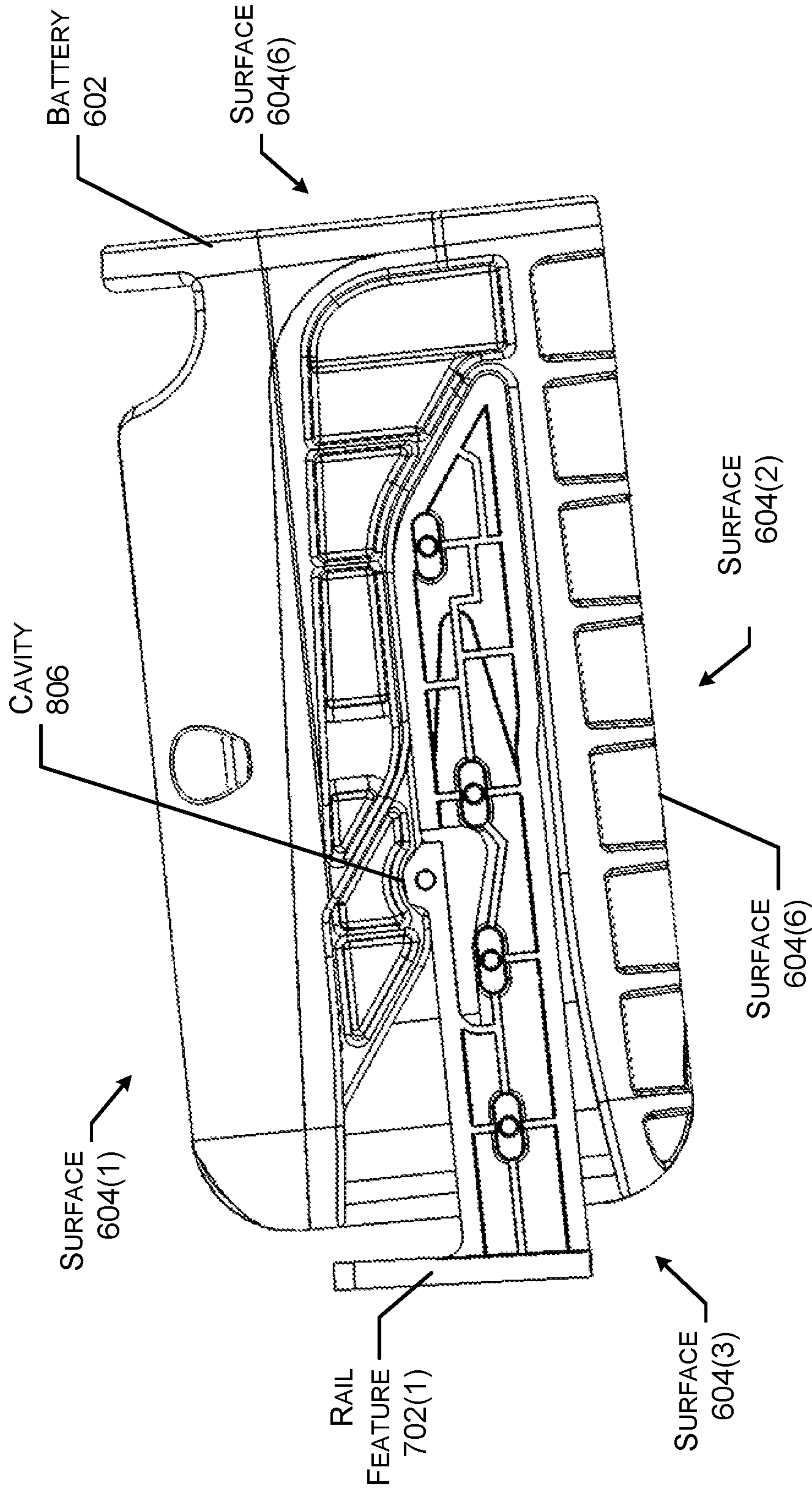


FIG. 8B

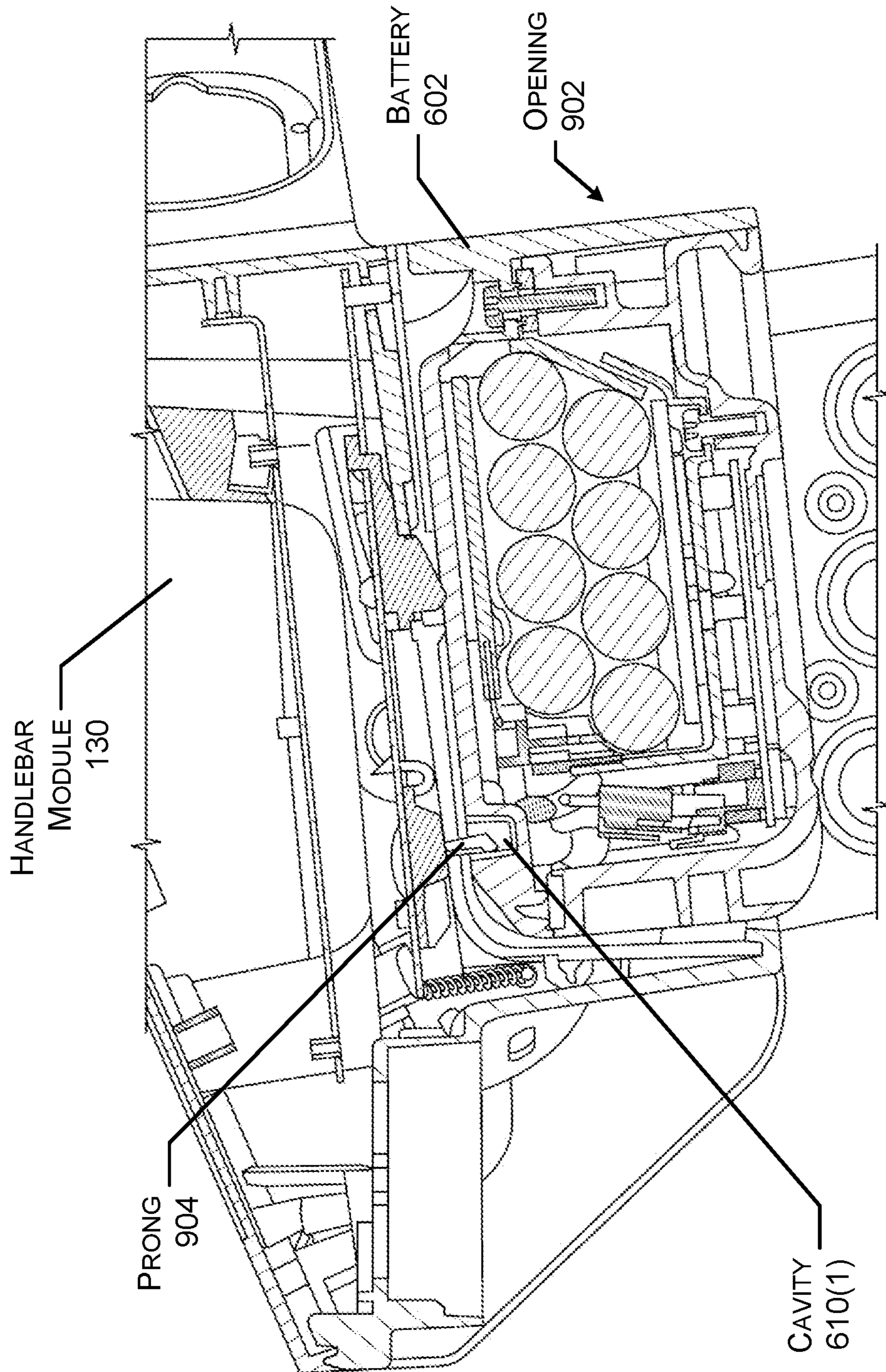


FIG. 9

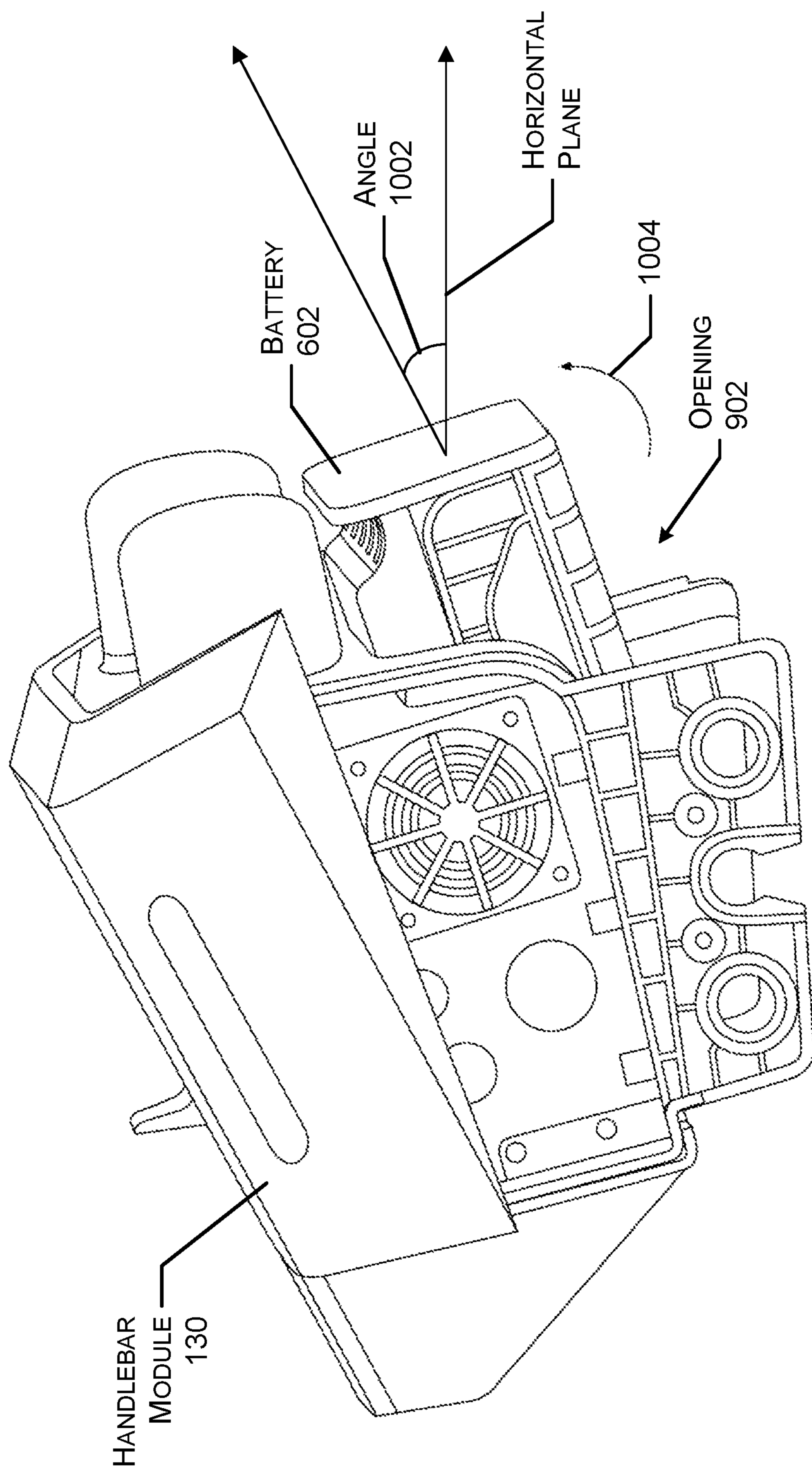


FIG. 10



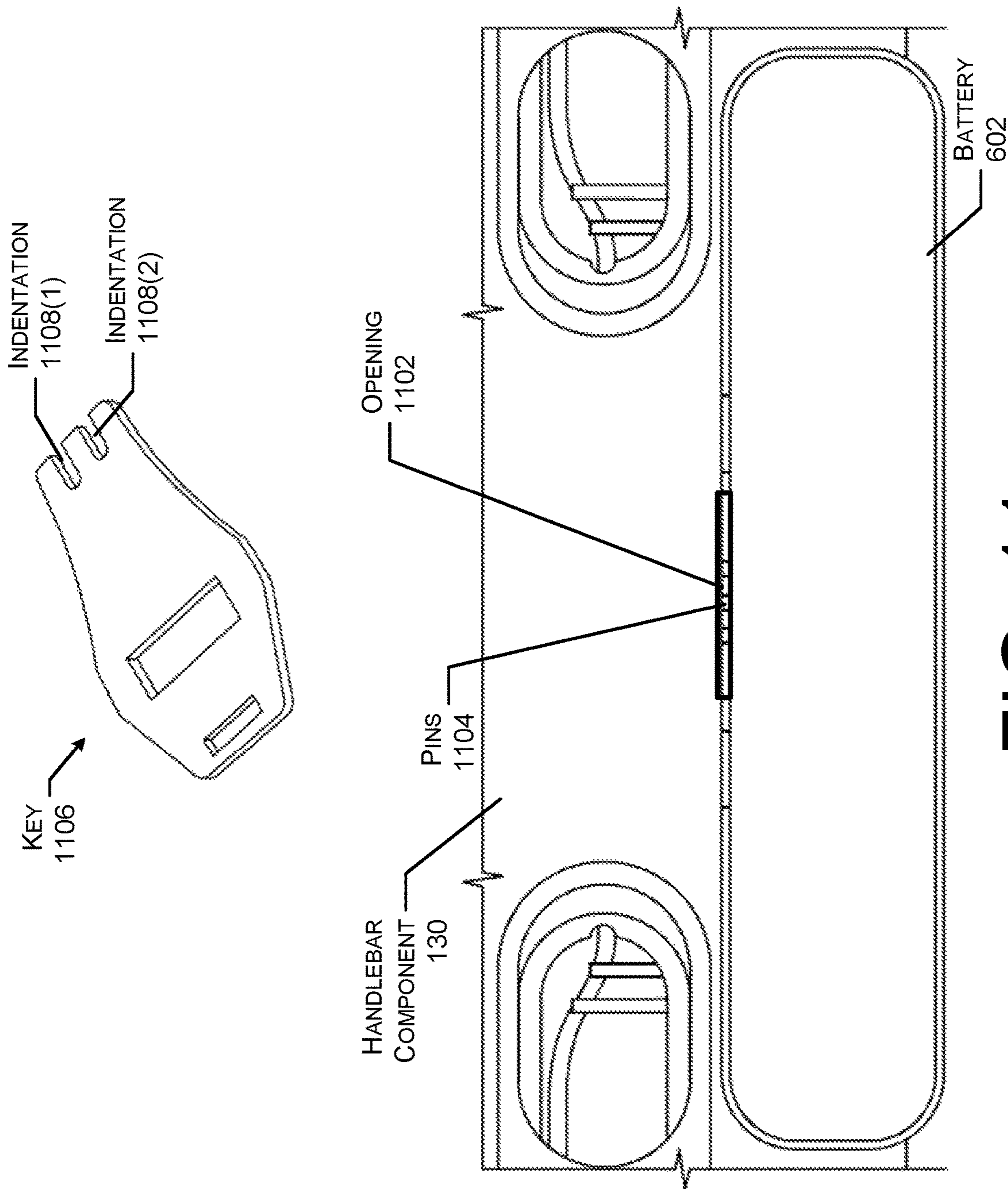


FIG. 11

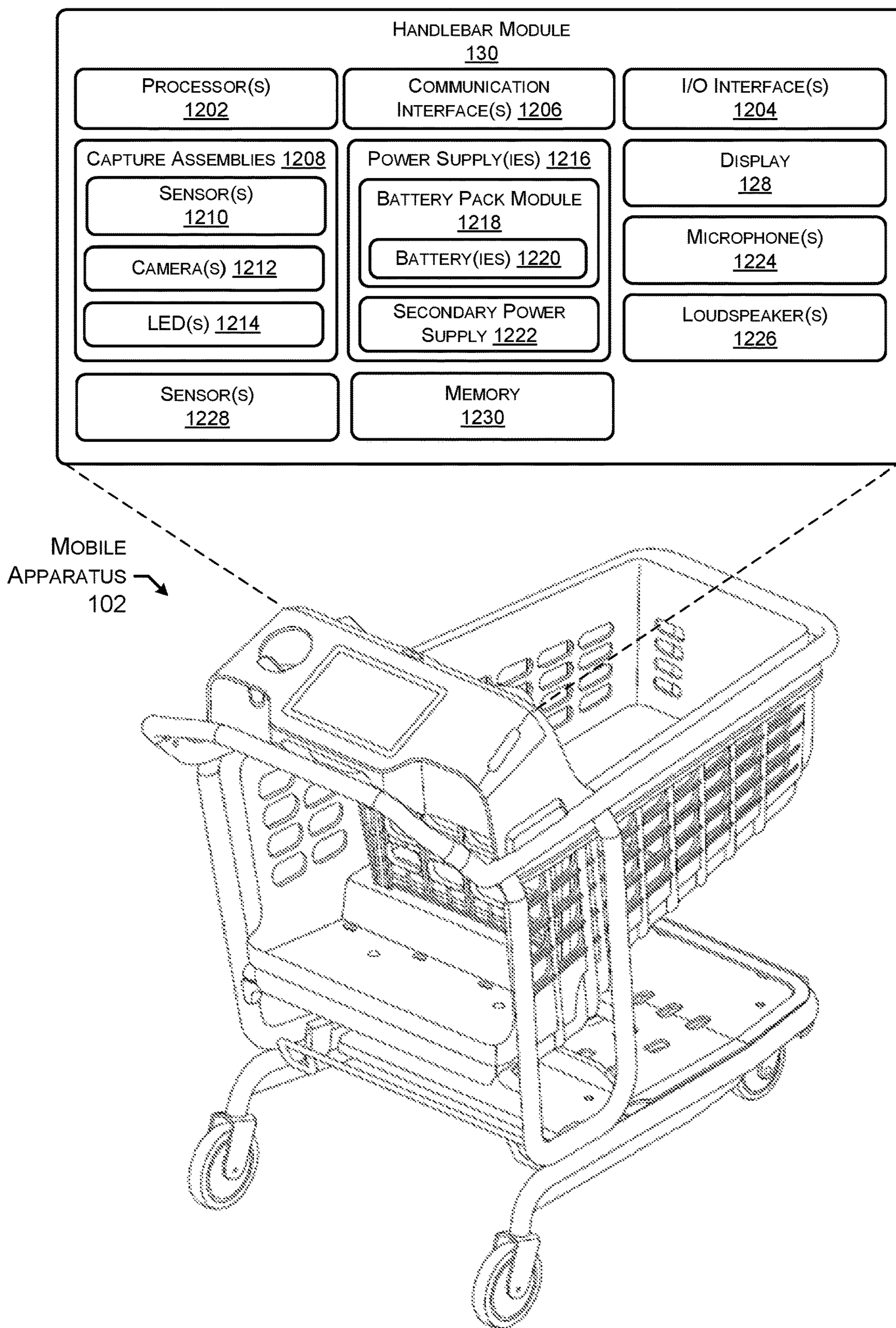


FIG. 12

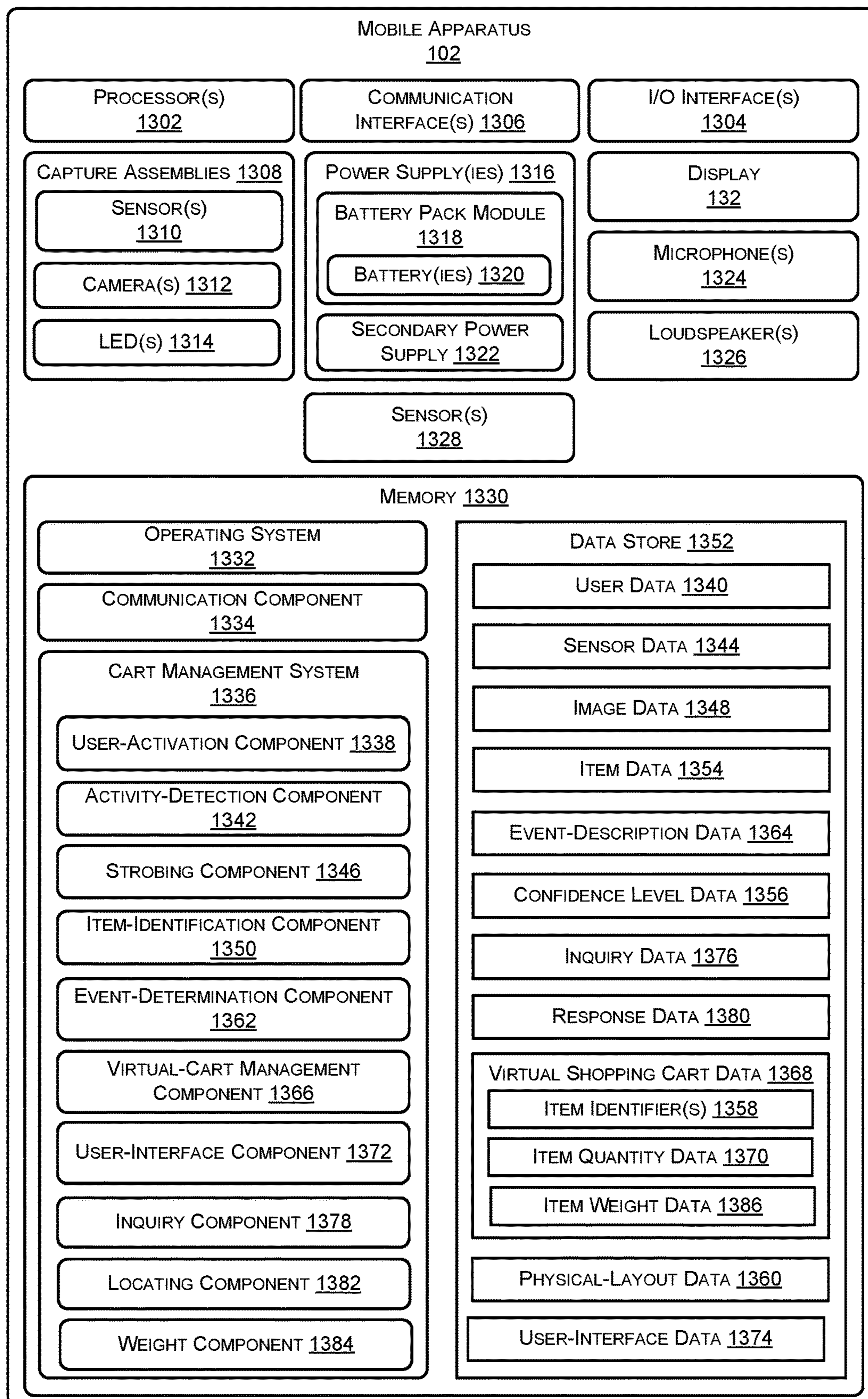


FIG. 13

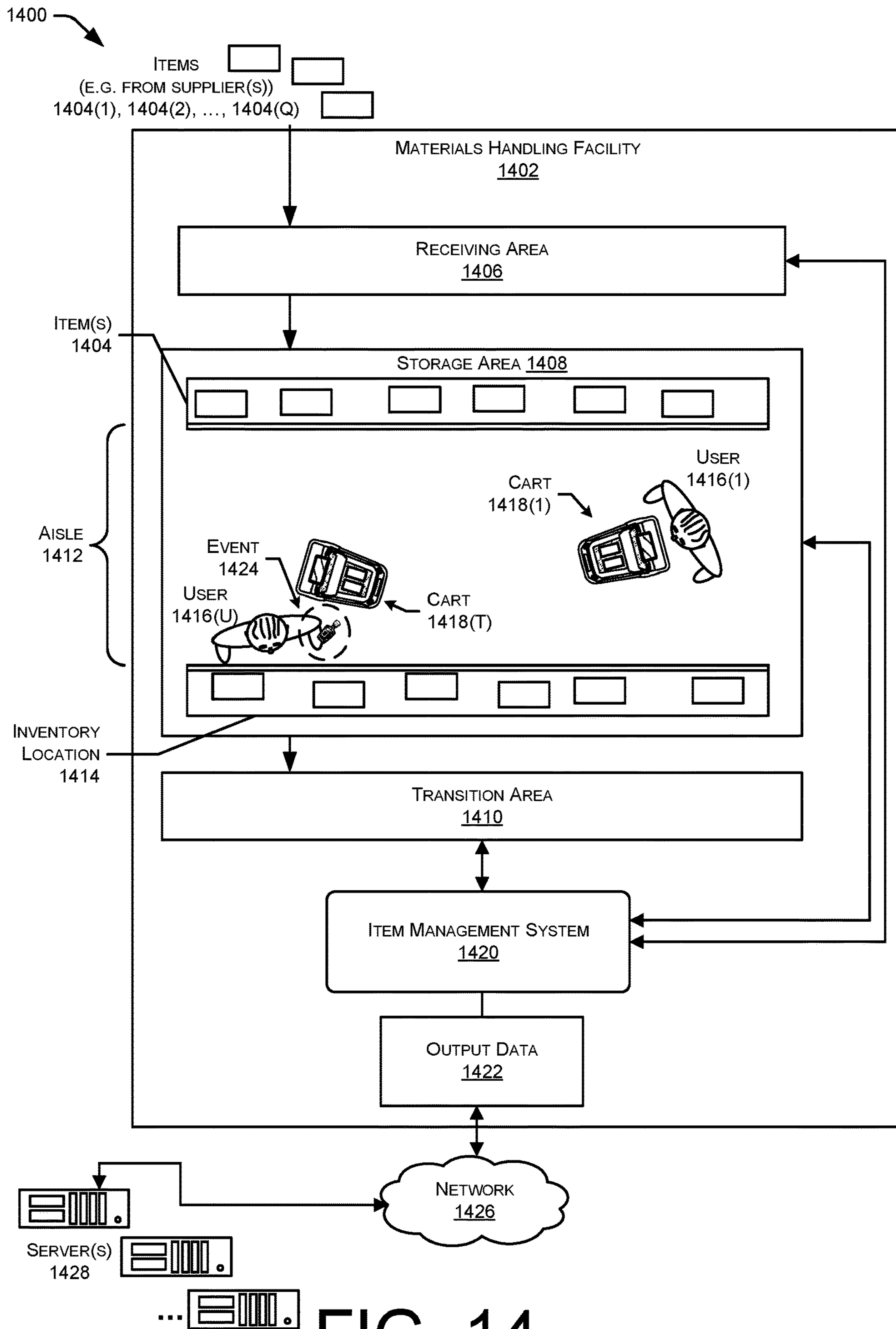


FIG. 14

## ITEM IDENTIFYING MOBILE APPARATUS

## BACKGROUND

Retail stores maintain an inventory of items in customer-accessible areas such that customers can pick items from the inventory for purchase, rental, and so forth. For example, a customer may take items from shelves located within the store and place the items in a shopping cart. When the customer is finished identifying and retrieving the items, the customer may transport the items, using the shopping cart, to a check-out destination within the store, such as a cashier or dedicated self-checkout stand. In some circumstances, the shopping cart may include sensors, such as cameras and weight sensors, that are configured to determine the items that are placed into the shopping cart by the customer. In these circumstances, the shopping cart may then update a list of items for the customer, display the list of items to the customer, and/or send the list of items to a system for processing of a transaction for the items.

## BRIEF DESCRIPTION OF FIGURES

The detailed description is set forth with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical items or features.

FIGS. 1A-1C illustrate an example of a mobile apparatus for identifying items, in accordance with examples of the present disclosure.

FIG. 2 illustrates a top view of the mobile apparatus, in accordance with examples of the present disclosure.

FIG. 3 illustrates a basket of the mobile apparatus that includes a gate, in accordance with examples of the present disclosure.

FIGS. 4A-4B illustrate a view of a bottom of the basket of the mobile apparatus, in accordance with examples of the present disclosure.

FIG. 5 illustrates another view of the bottom of the basket, in accordance with examples of the present disclosure.

FIG. 6 illustrates an example of a battery of the mobile apparatus, in accordance with examples of the present disclosure.

FIG. 7 illustrates an example of a rail system for guiding the battery into an opening of the mobile apparatus during installation of the battery, in accordance with examples of the present disclosure.

FIG. 8A illustrates an example of preventing the battery from being installed improperly, in accordance with examples of the present disclosure.

FIG. 8B illustrates an example of inserting the battery properly, in accordance with examples of the present disclosure.

FIG. 9 illustrates an example of securing the battery within the mobile apparatus, in accordance with examples of the present disclosure.

FIG. 10 illustrates an example of removing the battery from the mobile apparatus, in accordance with examples of the present disclosure.

FIG. 11 illustrates an example of a locking mechanism for the battery, in accordance with examples of the present disclosure.

FIG. 12 illustrates an example of components of a handlebar module, in accordance with examples of the present disclosure.

FIG. 13 illustrates example components of the mobile apparatus configured to support at least a portion of functionality of an item management system, in accordance with examples of the present disclosure.

FIG. 14 is an example process for using capacitive sensor(s) of an inventory location to detect item events, in accordance with examples of the present disclosure.

## DETAILED DESCRIPTION

This disclosure describes, in part, mobile apparatuses that use sensors to detect items. For instance, a mobile apparatus, such as a shopping cart, may include at least a main frame, a chassis that attaches to the main frame, a basket that attaches to the chassis, and sensor(s) disposed between the basket and the chassis. In some examples, the basket attaches to the chassis such that the basket does not contact the main frame during operation (e.g., there is an air gap around the perimeter of the basket and the main frame). The mobile apparatus may further include a shelf that extends off the basket and a moveable gate that separates a receptacle of the basket from a receptacle of the shelf. This way, a user may be able to separate item(s) placed within the receptacle of the basket from item(s) placed within the receptacle of the shelf. Additionally, the mobile apparatus may include a handlebar module that includes at least a display, additional sensor(s), and an opening for receiving a removable battery that provides power to the electrical components of the mobile apparatus. The mobile apparatus may be configured to use the sensor(s) to identify items placed within the receptacle(s), use the display to notify the user about the identified item(s), and/or send data representing the items to one or more computing devices.

For more detail, the mobile apparatus may include a frame (referred to, in some examples, as the “main frame” or an “upper frame”) that includes, or supports, components of the mobile apparatus. For example, a top portion of the main frame may support at least the handlebar module while a bottom portion of the main frame supports at least a chassis. The chassis may include any shape, such as an “X” shape, a square, a circle, a triangle, and/or the like, and support one or more sensors of the mobile apparatus. For example, the chassis may include the “X” shape and support a weight sensor, where a first loadcell of the weight sensor is disposed proximate to a first end of the chassis, a second loadcell of the weight sensor is disposed proximate to a second end of the chassis, a third loadcell of the weight sensor is disposed proximate to a third end of the chassis, and a fourth loadcell of the weight sensor is disposed proximate to a fourth end of the chassis. While this example describes the chassis as supporting four loadcells of the weight sensor, in other examples, the chassis may support any number of loadcells of the weight sensor.

The chassis may further include, and/or support, the basket. The basket may include a bottom having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.), one or more sides (e.g., three sides, four sides, etc.) protruding from the bottom to define a receptacle, and a top having a perimeter that defines an opening of the receptacle to receive items that are placed within the basket. In some examples, the sides of the basket may include a pattern that is configured to reduce flexing of the basket. For example, the sides of the basket may include a ribbed pattern, where the ribbed pattern is configured to reduce the flexing of the sides the basket when pressure is applied to the sides. In some examples, this pressure may be applied to the sides by items placed within the basket, such as when the

items are contacting the sides of the basket. By reducing the flexing of the sides of the basket using such a pattern, the basket may maintain that air gap between the basket and the main frame.

In some examples, the basket, such as one of the sides of the basket, may include a gate that is configured to move between a first position (which may be referred to, in some examples, as a “closed position”) and a second position (which may be referred to, in some examples, as an “open position”). In such examples, the bottom of the basket may include feature(s), such as groove(s), notch(es), channel(s), trench(es), and/or the like, that are configured to receive an additional feature(s), such as fastener(s), clasp(s), snap(s), extension(s), and/or the like of the gate when the gate is in the first position. For example, and as described in more detail below, the additional feature(s) of the gate may be configured to insert into the feature(s) of the basket such that that the gate cannot move laterally (e.g., to the sides) while in the first position. However, even when the gate is laterally secured to the basket, the gate may still be able to move from the first position to the second position, such as when a force is applied to a back of the basket (which is described in more detail below).

As described above, the basket attaches to the chassis such that the basket is prevented from contacting the main frame of the mobile apparatus. For example, the basket may be attached to the chassis such that there is an air gap between the perimeter of the basket and the top of the main frame when the mobile apparatus is being utilized by a user. This way, if the user contacts the main frame, such as to lean on the main frame to place an item within the receptacle of the basket, the weight of the user does not impact the weight sensor disposed on the chassis. In some examples, one or more fastener may be used to secure the basket to the chassis. As described herein, a fastener may include, but is not limited to, an expansion joint, a screw, a bolt, a mold, tape, a welding material, and/or any other mechanism that may be used to attach the basket to the chassis. For example, such as when the chassis includes the “X” shape, the one or more fasteners may include a first fastener (e.g., a first expansion joint) disposed proximate to a first end of the chassis, a second fastener (e.g., a second expansion joint) disposed proximate to a second end of the chassis, a third fastener (e.g., a third expansion joint) disposed proximate to a third end of the chassis, and a fourth fastener (e.g., a fourth expansion joint) disposed proximate to a fourth end of the chassis.

In some examples, one or more of the fasteners may be configured to align the basket onto the chassis in order to maintain the gap between the basket and the main frame. For example, the chassis may include opening(s), where fastener(s) (e.g., screw(s)) attach to the basket through the opening(s). In such an example, the opening(s) may be configured to allow for adjusting the location of the basket on the chassis in order to maintain the gap. For instance, the fastener(s) that pass through the opening(s) may be configured to move side-to-side within the opening(s) to adjust the location of the basket on the chassis. For example, the fastener(s) may be configured such that a user may loosen the fastener(s), adjust the location of the basket on the chassis to ensure that the gap remains between the basket and the main frame, and then tightened the fastener(s) in order to secure the basket at the location on the chassis. In some examples, the mobile apparatus includes a number of these fastener(s). The number may include, but is not limited to, one fastener, two fasteners, five fasteners, eight fasteners, ten fasteners, and/or any other number of fasteners.

In some examples, the mobile apparatus may include a bar that is configured to protect one or more components of the mobile apparatus, such as the handlebar module. For example, the bar may extend between at least a first side of the main frame to a second, opposite side of the main frame. As such, and in some examples, the bar may be configured to protect the handlebar module by preventing the gate from contacting the handlebar module when the gate moves between the first position and the second position. Additionally, in some examples, the bar may be configured to protect the handlebar module by preventing an additional basket of an additional mobile apparatus from contacting the handlebar module, such as when the mobile apparatuses are nested.

In some examples, the mobile apparatus may include one or more other components that help protect the connection between the basket and the chassis. For a first example, such as when the chassis includes the weight sensor with the loadcell(s), the mobile apparatus may include one or more first components that are located proximate to the loadcell(s), where the first component(s) operate as stops when a large force is applied downward on the basket (e.g., when a user leans onto the basket). The first component(s) may include raised area(s), such as protrusion(s), lip(s), flange(s), and/or the like. For a second example, the mobile apparatus may include one or more second components that operate to prevent horizontal movement of the basket with respect to the chassis. For instance, the second component(s) may include pin(s) that bottom out within hole(s) when there is a horizontal force applied to the basket. Still, for a third example, the mobile apparatus may include one or more third components that operate to prevent a separating (e.g., a lifting) of the basket from the chassis. While these are just a couple examples of component(s) that help protect the connection between the basket and the chassis, in other examples, the mobile apparatus may include additional and/or alternative components to help protect the connection between the basket and the chassis.

In some examples, the mobile apparatus may include another compartment, separate from the basket, for holding items. For example, the mobile apparatus may include a shelf that is coupled to and extends substantially horizontally from the basket. In such an example, the shelf may extend from a side of the basket that is closest to a user when the user is operating the mobile apparatus (e.g., a back side of the basket). The shelf may include a bottom having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.), one or more sides (e.g., four sides, etc.) protruding from the bottom to define a receptacle, and a top having a perimeter that defines an opening of the receptacle to receive items that are placed within the shelf. In some examples, one or more of the sides of the shelf may include a portion of one or more of the sides of the basket. For example, the basket and the shelf may share the same left and right sides. Additionally, the gate of the basket may separate the receptacle of the basket from the receptacle of the shelf.

The mobile apparatus may further include a handlebar module that is coupled to the main frame. The handlebar module may include one or more sensors (e.g., camera(s), scanner(s), proximity sensor(s), motion sensor(s), etc.), one or more lights, a display, and/or any other type of electronic device. Additionally, the handlebar module may include an opening for receiving the removable battery that provides power to the electrical components of the mobile apparatus. In some examples, the mobile apparatus may include a rail system that guides the battery into the opening when installing the battery into the mobile apparatus and/or guides the

battery out of the opening when removing the battery from the mobile apparatus. For example, the opening may include a first rail feature that is configured to “slide into” a second rail feature of the battery when an associate is inserting the battery into the opening and/or removing the battery from the opening. In some examples, the rail system guides the battery using an angle such that the battery may be removed from and/or inserted into the mobile apparatus even when the mobile apparatus is “nested” with other mobile apparatus(es).

In some examples, the opening may further include a latching system, such as prong(s) and/or spring-loaded ram(s), that insert into one or more cavities of the battery when the battery is inserted into the opening. This way, the latching system may be configured to both secure the battery within the opening (e.g., lock the battery in place) and offload impact forces directly to the housing of the handlebar module. In some examples, such as when the latching system includes the prong(s), the battery may be unlatched using a key that is inserted into another opening. For example, the key may be configured to access lifter(s) associated with the prong(s) in order to release the battery such that the battery may be removed from the opening of the handlebar module. In examples where the mobile apparatus includes the key, the mobile apparatus may further include security features(s), such as pin(s), that are designed to only allow access to the key for unlatching the battery. For example, if a user of the mobile apparatus attempts to use a different type of apparatus to unlatch the battery, the pin(s) may be configured to prevent the apparatus from accessing the lifter(s) of the prong(s).

The main frame of the mobile apparatus may be connected to a wheel frame that includes components for providing mobility to the mobile apparatus. For instance, the wheel frame may support one or more wheel castors to enable movement of the mobile apparatus along a surface. The wheel castors may include one or more wheels, axles, forks, joints or other components which enable the mobile apparatus to travel on various surfaces. For instance, in some examples, each of the wheel castors may include a single wheel provided on an axle within a fork, or two or more wheels provided on such an axle. In some other examples, the wheel castors may include two or more axles. Alternatively, in still other examples, a single caster may be provided in lieu of the multiple wheel castors.

In some examples, the bottom of the mobile apparatus may include a similar structure as the top of the mobile apparatus. For example, an additional chassis may be attached to the wheel frame. The additional chassis may include any shape, such as an “X” shape, a square, a circle, a triangle, and/or the like, and support one or more sensors of the mobile apparatus. For example, the additional chassis may include the “X” shape and support a weight sensor, where loadcell(s) are disposed at various location(s) on the additional chassis. The additional chassis may further include, and/or support, a tray. The tray may include a bottom having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.). In some examples, the tray may further include a separator that separate a first portion of the tray (e.g., a front portion of the tray) from a second portion of the tray (e.g., a back portion of the tray).

In some examples, the tray attaches to the additional chassis such that the tray is prevented from contacting the wheel frame of the mobile apparatus. For example, the tray may be attached to the chassis such that there is an air gap between the perimeter of the tray and the main frame when the mobile apparatus is being utilized by a user. This way, if

the user contacts the wheel frame, such as to step on the wheel frame, the weight of the user does not impact the weight sensor(s) disposed on the additional chassis. Additionally, in some examples, the tray may include lips that extend over the wheel frame. By including these lips, items that are placed on the tray may be unable to contact the wheel frame. As such, all of the weight of the items placed on the tray may be measured by the weight sensor(s) located underneath the tray.

In some examples, the mobile apparatus may be configured to identity items and/or characteristics associated with the items that are placed within the receptacle(s) of the mobile apparatus. For a first example, the mobile apparatus may use the weight sensor that is associated with the chassis in order to determine the weight of an item that is placed within the receptacle of the basket and/or within the receptacle of the shelf. When the weight sensor includes four loadcells, the mobile apparatus may determine the weight using data received from each of the loadcells. For instance, the mobile apparatus may use the data to determine a respective weight measured by each of the loadcells and then determine the total weight using the measured weights (e.g., determine the total weight by adding the measured weights together). Additionally, to determine the weight of the item placed within the basket, the mobile apparatus may determine the weight as a difference between a first weight measured before the item was placed within the receptacle and a second weight measured after the item is placed within the receptacle. In some examples, the mobile apparatus may then be configured to determine an identity of the item, a price of the item that is based on the weight, and/or any other characteristic associated with the item.

For a second example, the mobile apparatus may use other sensor(s), such as camera(s), scanner(s), and/or the like, to determine an identifier of an item placed within the receptacle(s). The identifier may include a code (e.g., a barcode, a Quick Response (QR) code, etc.), a label (e.g., a name, a brand, etc.), a logo, and/or any other type of identifier that may be placed on an item. The mobile apparatus may then be configured to use the identifier in order to identify the item. For instance, if the identifier includes a barcode, then the mobile apparatus may be configured to identify the item using the barcode. In some examples, the mobile apparatus may then associate the weight determined using the weight sensor with the identified item. For example, if the item is priced per unit weight, the mobile apparatus may associate the weight with the item and then determine the price of the item using the weight.

For a third example, and similar to the weight sensor of the basket, the mobile apparatus may use the weight sensor that is associated with the tray in order to determine the weight of an item that is placed on the tray. When the weight sensor includes multiple loadcells, the mobile apparatus may determine the weight using data received from each of the loadcells. For instance, the mobile apparatus may use the data to determine a respective weight measured by each of the loadcells and then determine the total weight using the measured weights (e.g., determine the total weight by adding the measured weights together). Additionally, to determine the weight of the item placed on the tray, the mobile apparatus may determine the weight as a difference between a first weight measured before the item was placed on the tray and a second weight measured after the item is placed on the tray. In some examples, the mobile apparatus may then be configured to determine an identity of the item, a price of the item that is based on the weight, and/or any other characteristic associated with the item.

In either of these examples, the mobile apparatus may then be configured to update a virtual shopping cart for a user, where the virtual shopping cart represents the item(s) that have been placed within the receptacle(s), item(s) that have been placed on the tray, weight(s) of the item(s), price(s) of the item(s), and/or any other information. Additionally, the mobile apparatus may be configured to use the display associated with the handlebar module to present the information to the user. This way, the user is provided with the most updated information associated with the shopping session while the user continues to place new items in the mobile apparatus.

By configuring the mobile apparatus such that the basket is attached to the chassis and prevented from contacting the main frame, the weight sensor(s) located between the basket and the chassis may be configured to only measure the weight of item(s) placed within the receptacle(s) of the mobile apparatus. For example, if a user contacts the main frame during operation of the mobile apparatus, such as by leaning on the main frame or pulling on the main frame, the force from the user may not be transferred from the main frame and to the basket. As such, the weight sensor(s) may not measure the force that is applied to the main frame by the user. This may help increase the accuracy of the mobile apparatus when using the weight to identify the characteristic(s) of the item(s) placed within the receptacle(s).

FIGS. 1A-1C illustrate an example of a mobile apparatus 102 for identifying items, in accordance with examples of the present disclosure. The mobile apparatus 102 may include a main frame 104(1)-(4) (also referred to as a “main frame 104”). As shown, the main frame 102 may include at least a top portion 104(1), side portions 104(2), a front portion 104(3), and a bottom portion 104(4) (illustrated at least in FIGS. 4A-4B). The top portion of the main frame 104(1) may also include a handlebar 106 that a user uses to push the mobile apparatus 102. The main frame 104 may be made of plastic, wood, metal, composites, or any other material and/or combinations of materials. As shown, the main frame 104 may include, and/or support, the other components of the mobile apparatus 102.

For example, the main frame 104 (e.g., the bottom portion 104(4)) may support a chassis 108. As shown in more detail with regard to FIGS. 4A-4B, the chassis 108 may include any shape, such as an “X” shape, a square, a circle, a triangle, and/or the like, and support one or more sensors of the mobile apparatus 102. For example, the chassis 108 may include the “X” shape that supports a weight sensor, where a first loadcell of the weight sensor is disposed proximate to a first end of the chassis, a second loadcell of the weight sensor is disposed proximate to a second end of the chassis, a third loadcell of the weight sensor is disposed proximate to a third end of the chassis, and a fourth loadcell of the weight sensor is disposed proximate to a fourth end of the chassis. While this example describes the weight sensor as include four loadcells, in other examples, the chassis 108 may include any number of loadcells. Additionally, the chassis 108 may be made of plastic, wood, metal, composites, or any other material and/or combinations of materials.

The chassis 108 may further include, and/or support, a basket 110. The basket 110 may comprise a bottom 112 having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.), sides 114(1)-(3) (also referred to as “sides 114”) protruding from the bottom 112 to define a receptacle, and a top 116 having a perimeter that defines an opening of the receptacle to receive items that are placed within the basket 110. In the example of FIGS. 1A-1B, the sides 114 of the basket 110 (as well as a gate 118

described below) include a ribbed pattern. As shown, the ribbed pattern may include openings 120 (although only one is labeled for clarity reasons) that are rectangular in shape, but with circular ends. However, in other examples, the openings may include any other shape. The sides of the basket 114 further include protrusions 122 (although only one is labeled for clarity reasons) that extend from the bottom 112 of the basket 110 to the top 116 of the basket 110 and/or laterally along the sides 114 of the basket 110.

In some examples, and as described in more detail here, the openings 120 and/or the protrusions 122 are configured to strengthen the basket 110, while also maintaining an overall lightweight design for the basket 110. For example, the openings 120 and/or the protrusions 122 may be configured to reduce the flexing that occurs to the sides 114 (as well as the gate 118) when forces are applied. For instance, when a user places an item within the basket 110 such that the item is pressed against a side 114(2) of the basket 110 (e.g., the item is leaning on the side 114(2)), the openings 120 and/or the protrusion 122 may be designed to reduce the flexing that occurs with respect to the side 114(2) such that the side 114(2) does not contact the main frame 104(1). This may maintain the are gap between the basket 110 and the main frame 104(1).

In some examples, the openings 120 may be configured to reduce the overall weight of the basket 110 while the protrusion 122 may be configured to provide additional strength to the basket 110. For example, by including the opening 120, the basket 110 may require less material, which will reduce the overall weight of the basket 110. However, this reducing of the overall weight of the basket 110 may initially also reduce the strength of the basket 110. As such, the protrusion 122 may be configured to provide extra material in order to again increase the strength of the basket 110. Additionally, the design of the protrusions 122, which are again both horizontally and vertically aligned along the sides 114 of the basket 110, may provide for the greatest increase in the strength for the basket 110. As such, by including both the openings 110 120 and the protrusions 122, the overall weight of the basket 110 is reduced while the overall strength of the basket 110 is still increased.

Additionally, the basket 110 also includes a gate 118 that is configured to move between the first position, which is illustrated in the example of FIGS. 1A-1C, and the second position, such as an open position. As shown, the gate 118 is attached to both a top of the side 114(2) and a top of the side 114(3) of the basket 110 such that the gate 118 is able to move between the different positions. As will be illustrated and discussed more with regard to FIG. 3, the bottom 112 of the basket 110 may include feature(s), such as groove(s), notch(es), channel(s), trench(es), and/or the like, that are configured to receive an additional feature(s), such as fastener(s), clasp(s), snap(s), extension(s), and/or the like of the gate 118 when the gate 118 is in the first position. As described herein, the features of the gate 118 and the basket 110 may be configured to prevent lateral movement (e.g., sideways movement towards the side 114(2) and the side 114(3) of the gate 118 when the gate 118 is in the first position. However, even with the features, the gate 118 is still able to move between the first position and the second position.

The mobile apparatus 102 may also include a shelf 124 that is coupled to and extends substantially horizontally from the basket 110. For example, the shelf 124 may extend at a 0-degree horizontal angle, a 10-degree horizontal angle, a 20-horizontal degree angle, and/or any other horizontal angle from the bottom 112 of the basket 110. As shown, the



shelf **124** extends from a side of the basket **110** that is closest to a user when the user is operating the mobile apparatus **102** (e.g., a backside of the basket **110**). The shelf **124** may include a bottom **126** having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.), the sides **114(2)-(3)** protruding from the bottom **126**, and sides **128(1)-(2)** (also referred to as “sides **128**”) protruding from the bottom **126**. The bottom **126**, the sides **114(2)-(3)**, and the sides **128** define a receptacle, where a top of the receptacle has a perimeter that defines an opening of the receptacle to receive items that are placed within the shelf **124**. As shown, first portions of the sides **114(2)-(3)** may operate as the sides of the basket **110** while second portions of the sides **114(2)-(3)** operate as the sides of the shelf **124**. Additionally, the gate **118** may separate the shelf **124** from the basket **110**.

The shelf **124** may be made of plastic, wood, metal, composites, or any other material and/or combinations of materials. In some examples, the shelf **124** is made of the same material as the basket **110** while, in other examples, the shelf **124** is made of a different material than the basket **110**.

The mobile apparatus **102** may further include a handlebar module **130** that is coupled to the main frame **104**. The handlebar module **130** may include one or more sensors (e.g., camera(s), scanner(s), proximity sensor(s), motion sensor(s), etc.), one or more lights, a display **132**, and/or any other type of electronic device. Additionally, and as discussed in more detail with regard to FIGS. 6-11, the handlebar module **130** may include an opening for receiving a removable battery that provides power to the electrical components of the mobile apparatus **102**.

In some examples, the mobile apparatus **102** may include a bar **134** that is configured to protect one or more components of the mobile apparatus **102**, such as the handlebar module **130**. For instance, and as illustrated by the example of FIGS. 1A-1C, the bar **134** may extend between at least the side portions **104(2)** of the main frame **104**. As such, and in some examples, the bar **134** may be configured to protect the handlebar module **130** by preventing the gate **118** from contacting the handlebar module **130** when the gate **118** moves between the first position and the second position. Additionally, in some examples, the bar **134** may be configured to protect the handlebar module **130** by preventing an additional basket of an additional mobile apparatus from contacting the handlebar module **130**, such as when the mobile apparatuses are nested.

In some examples, the bar **134** may also be configured to help maintain a position of the gate **118** when the gate **118** is in the first position, which is illustrated by the example of FIGS. 1A-1C. For instance, the bar **134** may act as an upper support, while the feature(s) at the bottom of the gate **118** (which are illustrated in FIG. 3) act as bottom supports, when the gate **118** is in the first position. This may provide more stiffness for the gate **118**, which may help protect the basket **112** from contacting the main frame **104** when forces are applied to the basket **112**.

The main frame **104** of the mobile apparatus **102** may be connected to a wheel frame **136** that includes components for providing mobility to the mobile apparatus **102**. For instance, the wheel frame **136** may support wheel casters **138(1)-(4)** (also referred to as “wheel casters **138**”) to enable movement of the mobile apparatus **102** along a surface. The wheel casters **138** may include wheels, axles, forks, joints or other components which enable the mobile apparatus **102** to travel on various surfaces. For instance, in some examples each of the wheel casters **138** may include a single wheel provided on an axle within a fork, or two or more wheels

provided on such an axle. In some other examples, the wheel casters **138** may include two or more axles. Alternatively, in still other examples, a single caster **138** may be provided in lieu of the multiple wheel casters **138**.

As further illustrated in the example of FIGS. 1A-1C, the mobile apparatus **102** may include a tray **140(1)-(2)** (also referred to as a “tray **140**”). In some examples, the tray **140** is configured on the mobile apparatus **102** similar to the basket **110**. For example, an additional chassis may be attached to the wheel frame **136**. The additional chassis may include any shape, such as an “X” shape, a square, a circle, a triangle, and/or the like, and support one or more sensors of the mobile apparatus **102**. For example, the additional chassis may include the “X” shape and support a weight sensor, where loadcell(s) are disposed at various location(s) on the additional chassis. In some examples, the additional chassis is similar to the chassis **108** described herein. The additional chassis may further include, and/or support, the tray **140**. In some examples, the tray **140** attaches to the additional chassis such that the tray **140** does not contact the wheel frame **136**. For example, the tray **140** may be attached to the additional chassis such that there is an air gap between the perimeter of the tray **140** and the wheel frame **136**.

In the example of FIGS. 1A-1C, the tray **140** may include a bottom having a given shape (e.g., a quadrilateral shape, a circular shape, a triangular shape, etc.). The tray **140** may also include a separator **142** that separates the first portion of the tray **140**, which is represented by **140(1)**, from the second portion of the tray **140**, which is represented by **140(2)**. In some examples, and as shown, the bottom of the tray **140** may include a slope and openings such that substances, such as water, do not accumulate on the bottom of the tray **140**. The tray may also include divots, similar to the divots of the basket **110** illustrated in FIG. 2, for configuring and/or testing the weight sensor(s) located on the additional chassis.

As further illustrated in the example of FIGS. 1A-1C, the tray **140** may include lips **144(1)-(3)** (also referred to as “lips **144**”) that extend above the wheel frame **136**. By including the lips **144**, items that are placed on the tray **144** may be unable to contact the wheel frame **136**. This way, all of the weight of the items is measured by the weight sensor(s) located underneath the tray **140**.

FIG. 2 illustrates a top view of the mobile apparatus **102**, in accordance with examples of the present disclosure. As shown, the basket **110** is separated from the main frame **104** by gaps **202(1)-(3)** (also referred to as “gaps **202**”). For example, at least the first side **114(1)** is separated from the main frame **104** by the gap **202(1)**, the second side **114(2)** is separated from the main frame **104** by the gap **202(2)**, and the third side **114(3)** is separated from the main frame **104** by the gap **202(3)**. As described herein, a respective gap **202** may include, but is not limited to, 0.5 inches, 1 inch, 2 inches, and/or any other distance. As will be described in more detail below, the basket **110** may be separated from the main frame **104** in order to prevent the weight sensor(s) from measuring the weight of objects, such as the user, that contact the main frame **104** during normal operation of the mobile apparatus **102**.

The bottom **112** of the basket **110** may include spacers **204(1)-(3)** (also referred to as “spacers **204**”). In some examples, the spacers **204** include marking (e.g., stickers, colors, etc.) that are configured to indicate to a user where to place item carriers, such as bags, within the basket **110**. For instance, the spacers **204** may indicate that a first item carrier is to be placed at a front-left portion **206(1)** of the basket **110**, a second item carrier is to be placed at a

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front-right portion 206(2) of the basket 110, a third item carrier is to be placed at a back-left portion 206(3) of the basket 110, and/or a fourth item carrier is to be placed at a back-right portion 206(4) of the basket 110. Additionally, or alternatively, in some examples, the spacer 204 may include components, such as grooves or protrusions, that help secure the item carriers within the basket 110. For instance, the spacers 204 may secure a first item carrier at the front-left portion 206(1) of the basket 110, secure a second item carrier at the front-right portion 206(2) of the basket 110, secure a third item carrier at the back-left portion 206(3) of the basket 110, and/or secure a fourth item carrier at the back-right portion 206(4) of the basket 110. While the example of FIG. 2 only illustrates three spacers 204 that separate the basket 110 into four different portions 206(1)-(4), in other examples, the basket 110 may include any number of spacers 204 that separate the basket 110 into any number of portions.

In some examples, the bottom 112 of the basket 110 may further include divots 208(1)-(2) (also referred to as “divots 208”) that are used when calibrating and/or testing the weight sensor(s) of the mobile apparatus 102. For instance, when calibrating and/or testing the weight sensor(s), physical weight(s) may be placed on the divots. The weight sensor(s) may then generate sensor data representing the total weight within the basket 110. The mobile apparatus 102 may then be calibrated and/or tested using the total weight of the physical weight(s) placed within the basket 110 and the total weight of the weight measured by the weight sensor(s).

FIG. 3 illustrates the gate 118 of the mobile apparatus 102 being secured to the basket 110, in accordance with examples of the present disclosure. As shown, the bottom 112 of the basket 110 includes grooves 302(1)-(2) (also referred to as “grooves 302”) located at a back portion of the basket 110 and proximate to the gate 118. In the example of FIG. 3, the grooves 302 include a quadrilateral shape. However, in other examples, one or more of the grooves 302 may include any other shape, such as a triangular shape, a circular shape, and/or the like. Additionally, the grooves 302 may be configured such that the grooves 302 increase in depth from the front sides of the grooves 302 (e.g., the side that is closest to the front of the mobile apparatus 102) to the back sides of the grooves 302 (e.g., the side that is closest to the back of the mobile apparatus 102). Furthermore, the grooves 302 may be configured such that the grooves increase in width from the back sides of the grooves 302 to the front sides of the grooves 302.

The grooves 302 may be configured to secure the gate 118 when the gate 118 is in the first position. For instance, and as shown by the example of FIG. 3, the gate 118 may include tabs 304(1)-(2) (also referred to as “tabs 304”) that are configured to slide into the grooves 302 when the gate 118 is lowered from the second position to the first position. The tabs include a shape that is configured to cause the gate 118 to be secured, while in the first position, such that the gate 118 is not able to move side-to-side when in the first position. For example, a width of the tabs 304 may be substantially equal to a width of the grooves 302 such that the gate 118 cannot move side-to-side. This way, the gate 118 will not contact the main frame 104 of the mobile apparatus 102 when the gate is in the first position and a force is applied to the sides of the gate 118.

Additionally, based on the shapes of the grooves 302, the gate 118 may still be configured to move from the first position to the second position even when the tabs 304 of the gate 118 are within the grooves 302 of the basket 110. This

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is because the grooves 302 may only be configured to prevent the side-to-side movement of the gate 118 (e.g., movement towards the side 114(2) of the basket 110 and the side 114(3) of the basket 110). However, the grooves 302 do not prevent the bottom of the gate 118 from moving forward, such as towards the side 114(1) of the basket 110, when the gate 118 is moving from the first position to the second position (e.g., the bottom of the gate 118 is still able to swing upwards until the gate 118 is approximately parallel with the bottom 112 of the basket 110).

FIGS. 4A-4B illustrate a view of the bottom 112 of the basket 110 of the mobile apparatus 102, in accordance with examples of the present disclosure. As shown, the chassis 108 is attached to the bottom portion 104(4) below the basket 110. The basket 110 may then be attached to the chassis 108 using fasteners 402(1)-(8) (also referred to as “fasteners 402”). In the example of FIGS. 4A-4B, the chassis 108 includes an “X” shape. However, in other examples, the chassis 108 may include any other shape.

In the example of FIGS. 4A-4B, the basket 110 is attached to the chassis 108 using eight fasteners 402 while, in other examples, the basket 110 may be attached to the chassis 108 using any number of fasteners 402. Additionally, in the example of FIGS. 4A-4B, the fasteners 402(1)-(4) may include a first type of fastener while the fasteners 402(5)-(8) include a second type of fastener. In some examples, the first type of fastener may include bolts while the second type of fastener may include expansion joints. However, in other examples, the first type of fastener and/or the second type of fastener may include any other type of fastener.

As further illustrated in the example of FIGS. 4A-4B, the mobile apparatus 102 may include sensors located between the chassis 108 and the basket 110 at various sensor locations 404(1)-(4) (also referred to as “sensor locations 404”). For example, a first loadcell associated with a weight sensor may be located between the chassis 108 and the basket 110 at the first sensor location 404(1), a second loadcell associated with the weight sensor may be located between the chassis 108 and the basket 110 at the second sensor location 404(2), a third loadcell associated with the weight sensor may be located between the chassis 108 and the basket 110 at the third sensor location 404(3), and a fourth loadcell associated with the weight sensor may be located between the chassis 108 and the basket 110 at the fourth sensor location 404(4). While the example of FIGS. 4A-4B illustrate four different sensor locations 404 of where sensors may be located between the chassis 108 and the basket 110, in other examples, any number of sensors may be located at any number of sensor locations between the chassis 108 and the basket 110.

In some examples, the sensors are coupled to plates 406(1)-(2) (also referred to as “plates 406”) associated with the chassis 108. For example, a first loadcell located at the first sensor location 404(1) may be coupled to the plate 406(1), a second loadcell located at the second sensor location 404(2) may be coupled to the plate 406(1), a third loadcell located at the third sensor location 404(3) may be coupled to the plate 406(2), and a fourth loadcell located at the fourth sensor location 404(4) may be coupled to the plate 406(2). In other words, the loadcells are located between the plates 406 associated with the chassis 108 and the basket 110.

As further illustrated in the example of FIGS. 4A-4B, the mobile apparatus 102 may include adjustable components 408(1)-(2) (also referred to as “adjustable components 408”). While the example of FIG. 4A only labels two adjustable components 408 for clarity reasons, FIG. 4A

illustrates the mobile apparatus 102 as including eight adjustable components 408 (e.g., four adjustable components 408 in the front of the chassis 108 and four adjustable components in the back of the chassis 108). The adjustable components 408 may be configured to secure the basket 110 to the chassis 108, after the basket 110 is correctly aligned on the chassis 108, such that the basket 110 does not contact the main frame 104. In some examples, each adjustable component 408 may include at least an opening, such as a slot, located on the chassis 108 and a screw that is disposed through the opening and attached to the basket 110. For example, a user may loosen the screw, align the basket 110 onto the chassis 108 such that the basket 110 does not contact the main frame 104, and then tighten the screw in order to “lock” the basket 110 into position. While these examples describe the adjustable components 408 as including openings and screws, in other examples, the adjustable components 408 may include any other type of component that is capable of securing the basket 110 to the chassis 108. Additionally, while the example of FIGS. 4A-4B illustrate eight adjustable components 408, in other examples, the mobile apparatus 102 may include any number of adjustable components 408.

FIG. 4B illustrates locations of openings for wiring the electrical components, such as the sensor(s) (e.g., the weight sensor, the loadcells, etc.) of the mobile apparatus 102. As shown, the main frame 104 (e.g., the bottom portion 104(4)) includes four openings 410(1)-(4) (also referred to as “openings 410”) for the wiring. For example, in order to protect the wiring, the wiring may be placed within the main frame 104 so that a majority of the wiring is not exposed to the outside environment. As such, in order to attach the wiring to the electrical components, the main frame 104 may include the openings 410 so that the wiring is able to extend from within the main frame 104, to outside of the main frame 104, and then to the electrical components. While the example of FIG. 4B illustrates the main frame 104 as including four openings 410, in other examples, the main frame 104 may include any number of openings 410.

As further illustrated in the example of FIGS. 4A-4B, the chassis 108 may include eight openings 412(1)-(8) for wiring the electrical components of the mobile apparatus 102. As shown, the chassis 108 include two openings 412(1)-(2) located proximate to the third sensor location 404(3), two openings 412(3)-(4) located proximate to the fourth sensor location 404(4), two openings 412(5)-(6) located proximate to the first sensor location 404(1), and two openings 412(7)-(8) located proximate to the second sensor location 404(2). While the example of FIGS. 4A-4B illustrate the chassis 108 as including eight openings 412, in other examples, the chassis 108 may include any number of openings 412. Additionally, while the example of FIGS. 4A-4B illustrate the chassis 108 as including two respective openings 412 located proximate to each sensor location 404, in other examples, the chassis 108 may include any number of sensor openings located proximate to each sensor location 404.

In some examples, the openings 412 allow for electrically connecting the loadcells of the weight sensor to the components included in the handlebar module 130. For example, the opening 412(1) and/or the opening 412(6) may allow for wiring to electrically connect the sensor that is located at the sensor location 404(1) to the components included in the handlebar module 130. For the wiring, the wires that are connected to the sensor may enter the main frame 104(1) through the opening 412(1) and/or the opening 412(6), extend through the main frame 104(1) to a location that is

proximate to the handlebar module 130, and then connect to the components of the handlebar module 130. Similar wiring connections may be used to then connected each of the other sensors to the handlebar module 130 using the other openings 410 of the main frame 104(1).

FIG. 5 illustrate another view of the bottom 112 of the basket 110, in accordance with examples of the present disclosure. As shown, underneath the bottom of the basket 112 may include a protector component 502 that protects the mobile apparatus 102 (e.g., the weight sensor(s)) when forces are applied to the basket 112. For instance, and in the example of FIG. 5, the protector component 502 includes a washer and nut, where the mobile apparatus 102 is configured to include a clearance between the washer and the chassis 108 (e.g., frame places of the chassis 108). When a force is applied upward onto the basket 112 (e.g., in the z-direction), such that the basket 112 flexes up, the clearance is closed in order to protect the basket 112 and the sensor(s). While the example of FIG. 5 only illustrates a single protector component 502, in other examples, the mobile apparatus 102 may have more than one of these protector components.

In some examples, the mobile apparatus 102 may include one or more additional components that help protect the mobile apparatus 102 from forces. For example, the chassis 108, such as the plate of the chassis 108, may include pin(s) that extend through hole(s) in the main frame 104. These pin(s) are then configured to prevent lateral movement (e.g., in the x-direction and the y-direction) of the basket 112, such as when forces are applied to the sides 114(1)-(3) of the basket 112. For instance, the pin(s) may contact the side(s) of the hole(s) when forces are applied to the sides 114(1)-(3) of the basket 112, where the contacting of the side(s) prevents the further movement of the basket 112 in the lateral direction.

FIG. 6 illustrates an example of a battery 602 of the mobile apparatus 102, in accordance with examples of the present disclosure. As shown, the battery 602 may include a substantially cuboid shape that includes a top surface 604(1), a bottom surface 604(2), and four side surfaces 604(3)-(6). However, in other examples, the battery 602 may include a different shape, such as a cube, a cylinder, and/or the like. The example of FIG. 6 illustrates that the battery 602 may include an electrical connector 606 for electrically connecting the battery 602 to the mobile apparatus 102 and/or electrically connecting the battery 602 to an electrical component that recharges the battery 602. Additionally, the battery 602 may include cavities 608(1)-(3) (also referred to as “cavities 608”). As will be discussed further with regard to FIG. 9, the cavities 608 may be used to lock the battery 602 into position when the battery 602 is installed in the mobile apparatus 102. While the example of FIG. 6 illustrates the battery 602 as including three cavities 608, in other examples, the battery 602 may include any number of cavities.

Additionally, the example of FIG. 6 illustrates that the battery 602 may include a rail features 610 that helps guide the battery 602 into an opening of the handlebar module 130 when the battery 602 is inserted into the handlebar module 130. For instance, FIG. 7 illustrates an example of a rail system for guiding the battery 602 into the opening of the mobile apparatus 102 during installation of the battery 602, in accordance with examples of the present disclosure. As shown, a rail feature 702(1) (as well as a rail feature 702(2) that guides the other side of the battery 602) that may be located within the opening of the handlebar module 130 may insert into the rail feature 610 of the battery 602. Based on

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the shape of the rail feature 702(1) and the shape of the rail feature 610, the rail feature 702(1) may guide the battery 602 into the opening. Additionally, and during the installation, the battery 602 may lock into position.

In some examples, the rail feature 610 and the rail feature 702(1) may be configured to protect the battery 602 from being installed improperly. For instance, FIG. 8A illustrates an example of preventing the battery 602 from being installed improperly, in accordance with examples of the present disclosure. As shown, the rail feature 702(1) may include a connector 802 that is configured to insert into a cavity 804 of the rail feature 610 when the battery 602 is inserted improperly into the opening. In some examples, the inserting of the connector 802 into the cavity 804 prevents the battery 602 from being fully inserted into the opening. This may be designed in order to polarize the installation of the battery 602, which may protect the electrical connector 606 of the battery 602 and/or the electrical connector of the mobile apparatus 102 that connects to the electrical connector 606.

FIG. 8B illustrates an example of inserting the battery 602 properly, in accordance with examples of the present disclosure. As discussed herein, the rail feature 610 and the rail feature 702(1) may be configured to guide the battery 602, such as when the battery 602 is being inserted into an opening of the mobile apparatus 102 during installation of the battery 602. As such, when the battery 602 is properly inserted into the opening, the rail feature 702(1) may completely engage with the rail feature 610 in order to secure the battery 602 within the opening. Additionally, and as illustrated in the example of FIG. 8B, the connector 802 may insert into a cavity 806 of the rail feature 610, which helps secure the battery 602 within the opening.

Also, as discussed above, the cavities 608 may be used to lock the battery 602 into position. For instance, FIG. 9 illustrates an example of locking the battery 602 within the mobile apparatus 102, in accordance with examples of the present disclosure. As shown, the battery 602 is inserted into an opening 902 of the handlebar compartment 126 (where the opening 902 is further illustrated in FIG. 10). As also shown, the handlebar module 130 may include a prong 904 that is configured to insert into the cavity 608(1) of the battery 602 when the battery 602 is inserted into the opening 902. In some examples, the prong 904 may include a spring-loaded ram. While the example of FIG. 9 illustrates only prong 904 inserting into a single cavity 608(1), in other examples, the handlebar module 130 includes multiple prongs that insert into the cavities 608.

By using the prong to secure the battery 602 within the opening 902, the latching system may be configured to offload impact forces from the latching system directly to the mobile apparatus 102. This may help protect the battery 602 during installation, during removal, and/or during normal operation of the mobile apparatus 102.

In some examples, the mobile apparatus 102 may be configured such that the battery 602 is removed and/or installed at an angle. For instance, FIG. 10 illustrates an example of removing the battery 602 from the mobile apparatus 102, in accordance with examples of the present disclosure. As shown, the battery 602 is removed from the opening 902 of the handlebar module 130 at an angle 1002 with respect to the horizontal plane. In some examples, allowing the battery 602 to be removed and/or installed at the angle 1002 allows for easier access to the battery 602, such as when the mobile apparatus 102 is “nested” with other mobile apparatus(es).

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In some examples, and as illustrated by a curved arrow 1004, the rail system associated with the battery 602 also allows for the battery 602 to pivot when the battery 602 is removed and/or inserted into the opening 902 of the handlebar module 130. Similar to the angle 1002 at which the battery 602 is inserted and/or removed, allowing the battery 602 to pivot may also allow for easier access to the battery 602, such as when the mobile apparatus 102 is “nested” with other mobile apparatus(es).

In some examples, the battery 602 may be configured to lock into place within the opening 902 of the handlebar module 130. For instance, FIG. 11 illustrates an example of a locking mechanism for the battery, in accordance with examples of the present disclosure. As shown, the locking mechanism may include an opening 1102 that is located between the battery 602 and a portion of the handlebar module 130. Pins 1104 may be located at least partially within the opening 1102, where the pins 1104 are configured to prevent entry to lifters within the handlebar compartment 126 that lift the prongs (e.g., the prong 904). As such, and as also illustrated by the example of FIG. 11, a key 1106 may be designed such that the key 1106 passes through the pins 1104 and to the lifters for the prongs.

For instance, the key 1106 may include indentations 1108(1)-(2) (also referred to as “indentations 1108”) that allow the pins 1104 to pass through the key 1106 when the key 1106 is inserted into the opening 1102. This way, the key 1106 is able to access the lifters for the prongs, where the lifters cause the prongs to lift out of the cavities 608 of the battery 602. When the prongs are lifted out of the cavities 608, the battery 602 may be removed from the opening 902 of the handlebar module 130.

FIG. 12 illustrates example components of the handlebar module 130 configured to support at least a portion of the functionality of an item management system. The handlebar module 130 may include one or more hardware processors 1202 (processors) configured to execute one or more stored instructions. The processor(s) 1202 may comprise one or more cores. The handlebar module 130 may include one or more input/output (I/O) interface(s) 1204 to allow the processor(s) 1202 or other portions of the handlebar module 130 to communicate with other devices. The I/O interface(s) 1204 may comprise Inter-Integrated Circuit (I2C), Serial Peripheral Interface bus (SPI), Universal Serial Bus (USB) as promulgated by the USB Implementers Forum, and so forth. The I/O interface(s) 1204 may allow the various modules/components to communicate with each other and/or control each other.

The handlebar module 130 may also include one or more communication interfaces 1206. The communication interface(s) 1206 are configured to provide communications between the handlebar module 130 and other devices, such as the server(s), sensors, interface devices, routers, and so forth. The communication interface(s) 1206 may include devices configured to couple to personal area networks (PANs), wired and wireless local area networks (LANs), wired and wireless wide area networks (WANs), and so forth. For example, the communication interfaces 1206 may include devices compatible with Ethernet, Wi-Fi™, and so forth. The handlebar module 130 may also include one or more busses or other internal communications hardware or software that allow for the transfer of data between the various modules and components of the handlebar module 130.

The handlebar module 130 may also include the one or more capture assemblies 1208 that each include one or more sensors 1210, a camera 1212, and one or more LEDs 1214.

In some examples, the sensor(s) **1210** may comprise any type of sensor that is able to detect the presence of nearby objects without the need for physical contact (e.g., ToF sensor(s), PIR sensor(s), capacitive sensor(s), etc.). The cameras **1212** in each of the capture assemblies **1208** may 5 comprise any type of camera or imaging device configured to generate image data (and/or video data), or information descriptive of a plurality of picture elements or pixels. The LED(s) **1214** may be selectively activated to emit light at any wavelength, visible or non-visible to users. In some 10 examples, one or more capture assemblies **1208** may additionally, or alternatively, be facing downward into the basket **110** of the handlebar module **130**. Additionally, the handlebar module **130** may include one or more cameras **1212** that are outward facing in that generate image data representing the facility around the handlebar module **130**.

The handlebar module **130** may include one or more power supply(ies) **1216** to provide power to the components of the handlebar module **130**, such as a battery pack module **1218** (e.g., the battery **602**), which include one or more 20 batteries **1220**. The power supply(ies) **1216** may also include a secondary (e.g., internal) power supply **1222** to allow for hot swapping of battery pack modules **1218**, such as one or more capacitors, internal batteries, etc.

The handlebar module **130** may also include the display **122** configured to display content represented by image data, such as pictures, videos, user interface elements, and/or any other image data. The display **122** may comprise any type of display **122**, and may further be a touch screen to receive 25 touch input from a user. The handlebar module **130** may also include one or more microphones **1224** and one or more loudspeakers **1226** to facilitate a dialogue with a user, and/or to receive feedback from the user. The microphone(s) **1224** may capture sound representing the user's speech, and the loudspeaker(s) **1226** may output machine-generated words to facilitate a dialogue, prompt a user for feedback on an 30 item and/or for other information, and/or output other alerts or notifications.

The handlebar module **130** may also include other types of sensor(s) **1228**. As described herein, these sensor(s) may 40 proximity sensor(s), light sensor(s), and/or the like.

The handlebar module **130** may include one or more memories **1230** (e.g., in an electronics box module along with the processor(s) **1202**). The memory **1230** comprises one or more computer-readable storage media (CRSM). The 45 CRSM may be any one or more of an electronic storage medium, a magnetic storage medium, an optical storage medium, a quantum storage medium, a mechanical computer storage medium, and so forth. The memory **1230** provides storage of computer-readable instructions, data 50 structures, program modules, and other data for the operation of the handlebar module **130**. Examples of operations that may be performed by the handlebar module **130** are described with respect to FIG. **13**.

FIG. **13** illustrates example components of the mobile 55 apparatus **102** configured to support at least a portion of the functionality of an item management system. The mobile apparatus **102** may include one or more hardware processors **1302** (processors) (which may represent, and/or include, the processor(s) **1202**) configured to execute one or more stored 60 instructions. The processor(s) **1302** may comprise one or more cores. The mobile apparatus **102** may include one or more I/O interface(s) **1304** (which may represent, and/or include, the I/O interface(s) **1202**) to allow the processor(s) **1302** or other portions of the mobile apparatus **102** to 65 communicate with other devices. The I/O interface(s) **1304** may comprise Inter-Integrated Circuit (I2C), Serial Periph-

eral Interface bus (SPI), Universal Serial Bus (USB) as promulgated by the USB Implementers Forum, and so forth. The I/O interface(s) **1304** may allow the various modules/ components to communicate with each other and/or control 5 each other.

The mobile apparatus **102** may also include one or more communication interfaces **1306** (which may represent, and/or include, the communication interface(s) **1206**). The communication interface(s) **1306** are configured to provide communications between the mobile apparatus **102** and other 10 devices, such as the server(s), sensors, interface devices, routers, and so forth. The communication interface(s) **1306** may include devices configured to couple to personal area networks (PANs), wired and wireless local area networks 15 (LANs), wired and wireless wide area networks (WANs), and so forth. For example, the communication interfaces **1306** may include devices compatible with Ethernet, Wi-Fi™, and so forth. The mobile apparatus **102** may also include one or more busses or other internal communications hardware or software that allow for the transfer of data between the various modules and components of the mobile 20 apparatus **102**.

The mobile apparatus **102** may also include the one or more capture assemblies **1308** (which may represent, and/or include, the one or more capture assemblies **1208**) that each include one or more sensors **1310**, a camera **1312**, and one or more LEDs **1314**. In some examples, the sensor(s) **1310** may comprise any type of sensor that is able to detect the presence of nearby objects without the need for physical 25 contact (e.g., ToF sensor(s), PIR sensor(s), capacitive sensor(s), etc.). The cameras **1312** in each of the capture assemblies **1308** may comprise any type of camera or imaging device configured to generate image data (and/or video data), or information descriptive of a plurality of picture elements or pixels. The LED(s) **1314** may be selectively activated to emit light at any wavelength, visible or 30 non-visible to users. In some examples, one or more capture assemblies **1308** may additionally, or alternatively, be facing downward into the basket **110** of the mobile apparatus **102**. Additionally, the mobile apparatus **102** may include one or more cameras **1312** that are outward facing in that generate image data representing the facility around the mobile 35 apparatus **102**.

The mobile apparatus **102** may include one or more power supply(ies) **1316** to provide power to the components of the mobile apparatus **102**, such as a battery pack module **1318** 45 (e.g., the battery **602**), which include one or more batteries **1320**. The power supply(ies) **1316** may also include a secondary (e.g., internal) power supply **1322** to allow for hot swapping of battery pack modules **1318**, such as one or more capacitors, internal batteries, etc. 50

The mobile apparatus **102** may also include the display **132** configured to display content represented by image data, such as pictures, videos, user interface elements, and/or any other image data. The display **132** may comprise any type of display **132**, and may further be a touch screen to receive 55 touch input from a user. The mobile apparatus **102** may also include one or more microphones **1324** (which may represent, and/or include, the microphone(s) **1224**) and one or more loudspeakers **1326** (which may represent, and/or include, the loudspeaker(s) **1226**) to facilitate a dialogue with a user, and/or to receive feedback from the user. The microphone(s) **1324** may capture sound representing the user's speech, and the loudspeaker(s) **1326** may output 60 machine-generated words to facilitate a dialogue, prompt a user for feedback on an item and/or for other information, and/or output other alerts or notifications.

The mobile apparatus **102** may also include other types of sensor(s) **1328** (which may represent, and/or include, the sensor(s) **1228**). As described herein, these sensor(s) may include weight sensor(s) with loadcell(s), where, in some examples, the loadcell(s) are located between the basket **110** and the chassis **108**.

The mobile apparatus **102** may include one or more memories **1330** (which may represent, and/or include, the memory **1220**). The memory **1330** comprises one or more computer-readable storage media (CRSM). The CRSM may be any one or more of an electronic storage medium, a magnetic storage medium, an optical storage medium, a quantum storage medium, a mechanical computer storage medium, and so forth. The memory **1330** provides storage of computer-readable instructions, data structures, program modules, and other data for the operation of the mobile apparatus **102**. A few example functional modules are shown stored in the memory **1330**, although the same functionality may alternatively be implemented in hardware, firmware, or as a system on a chip (SOC).

The memory **1330** may include at least one operating system (OS) component **1332**. The OS component **1332** is configured to manage hardware resource devices such as the I/O interface(s) **1304**, the communication interface(s) **1306**, and provide various services to applications or components executing on the processor(s) **1302**. The OS component **1332** may implement a variant of the FreeBSD™ operating system as promulgated by the FreeBSD Project; other UNIX™ or UNIX-like variants; a variation of the Linux™ operating system as promulgated by Linus Torvalds; the Windows® Server operating system from Microsoft Corporation of Redmond, Wash., USA; and so forth.

One or more of the following components may also be stored in the memory **1330**. These components may be executed as foreground applications, background tasks, daemons, and so forth. A communication component **1334** may be configured to establish communications with one or more of the sensors, one or more of the servers, or other devices. The communications may be authenticated, encrypted, and so forth.

The memory **1330** may further store a cart management system **1336**. The cart management system **1336** is configured to provide the item-identifying functions (and other functions) provided by the mobile apparatus **102** as described herein. For example, the cart management system **1336** may be configured to detect items, identify items, and maintain a virtual shopping cart for a user of the mobile apparatus **102**.

The cart management system **1336** may include a user-activation component **1338** that performs operations for activating a shopping session using the mobile apparatus **102** on behalf of a user. For instance, a user may have previously registered for a user account with an operator of the facility to utilize various automated management services provided by an operator of the facility. The user may have registered for a user account, such as by providing user data **1340**, to automate payments made for items taken by the user and included a payment means (e.g., credit card, bank account number, etc.), and may have also provided an identification means in the user data **1340** to the user-activation component **1338** such that the mobile apparatus **102** can recognize the user. For instance, the user may have registered to identify themselves to the mobile apparatus **102** using any identification technique by the user-activation component **1338**, such as by providing the user data **1340** by presenting an identification means to a camera/scanner **1312** (e.g., presenting a driver's license, presenting a facility-

issued card, presenting a user identifier via a mobile phone, etc.), and/or speaking a predefined utterance that is captured by the microphone(s) **1324** (e.g., a name of the user, a predefined keyword, etc.). Once a user has identified themselves using the user-activation component **1338**, the user-activation component **1338** may open a shopping session where the mobile apparatus **102** identifies and track items retrieved by the user and placed in the mobile apparatus **102**.

The cart management system **1336** may additionally include an activity-detection component **1342** configured to detect items (or objects) within a particular proximity to the mobile apparatus **102**. For example, the capacitive sensor(s) **1328** may generate sensor data **1344**. The activity-detection component **1342** may then analyze the sensor data **1344** in order to determine a capacitance detected by the capacitive sensor(s) **1328**. Additionally, the activity-detection component **1342** may use the capacitance to perform one or more of the processes described herein to detect the presence of a user. For example, the activity-detection component **1342** may use the capacitance to determine if the user is located proximate to the mobile apparatus **102**, the user is located over the perimeter of the mobile apparatus **102**, determine if the user is located within the opening of the mobile apparatus **102**, determine if the user is in contact with the cart, and/or the like.

The cart management system **1336** may further include a strobing component **1346** configured to cause the LED(s) **1314** and/or shutters of the camera(s) **1312** to strobe according to different frequencies. As noted above, the LED(s) **1314** may emit light in any light spectrum (e.g., infrared, near infrared, visible, etc.). However, some items may have text and/or other marking printed thereon using dye-based color inks that have diminished and/or similar near infrared (NIR) absorbance. This may lead to compromised contrast between, and essentially “washing out” of many distinct features in the visible spectrum when viewed in NIR. Accordingly, in some examples it may be advantageous to cause the LED(s) **1314** to emit light in the visible spectrum. When generating image data **1348** using camera(s) **1312**, motion blur may appear when capturing fast moving objects. However, the motion blur may be reduced or eliminated by exposing the camera(s) **1312** imager for a short (e.g., sub-millisecond) durations. Accordingly, the strobing component **1346** may strobe the opening and closing of shutters of the camera(s) **1312** to limit the sensor exposure duration. Additionally, the strobing component **1346** may cause the LEDs **1314** to emit/strobe light at a particular frequency.

The cart management system **1336** may also include an item-identification component **1350** configured to analyze image data **1348** to identify an item represented in the image data **1348**. The image data **1348** may comprise information descriptive of a plurality of picture elements, or pixels, for one or more image frames (e.g., a still picture, multiple picture frames, video frames, etc.). The item-identification component **1350** may analyze the image data **1348** using various image processing techniques, or computer vision techniques. For instance, the item-identification component **1350** may extract a representation of an item depicted in the image data **1348** generated by at least one of the camera(s) **1312**. The representation may include identifying text printed on the item, colors or color schemes printed on the item, 2-D and/or 3D shapes of the item, and/or other techniques for extract a representation of the item. In some instances, the representation of the item depicted in the image data **1348** may comprise a numeric representation, such as a feature vector or a set of feature vectors.

In some examples, a data store **1352** stored in the memory **1330** may include item data **1354**, which may include representations of the items offered for acquisition at the facility. The item-identification component **1350** may compare the extracted represented of the item with the “gallery” or stored representations of the known items in the item data **1354**. In some instance, the item representation may include an indication of a barcode or SKU data for the item as recognized in, or extracted from, the image data **1348**. The item-identification component **1350** may determine confidence level data **1356** based on the comparisons with item representation in the item data **1354**. The item-identification component **1350** may determine, and assign, confidence levels indicating how likely it is that the item represented in the image data **1348** corresponds to an item from the item gallery in the item data **1354**. Based on the confidence level data **1356**, the item-identification component **1350** may determine an item identifier **1358** for the item in the image data **1348** (or multiple item identifiers **1358**) that corresponds to an item in the item data **1354** to which the item corresponds.

In some examples, the data store **1352** may include physical-layout data **1360** that is used by the item-identification component **1350** to determine the item. The physical-layout data **1360** may include or provide a mapping of physical locations within the physical layout of devices and objects such that the location of the mobile apparatus **102** may be utilized to determine an item stored nearby. The physical-layout data **1360** may indicate the coordinates within the facility of an inventory location, items stored at that inventory location, and so forth. In examples where the mobile apparatus **102** has location determining sensors (e.g., GPS, RFID, proximity, etc.), the location sensor data may be used to determine where in the store the user is located. In such examples, the item-identification component **1350** may access the physical-layout data **1360** to determine if a location associated with the event is associated with a location, and confidence levels for the corresponding representations of items in the item data **1354**. Continuing the example above, given the location within the facility of the event and image camera data, the physical-layout data **1360** may determine the items that may have been represented in generated images of the event.

The cart management system **1336** may further include an event-determination component **1362** to determine event-description data **1364** for the item in the image data **1348**. The event-determination component **1362** may determine if the user is adding an item to the mobile apparatus **102**, removing the item from the mobile apparatus **102**, etc., based on movement of the item and/or whether the item is shown in the image data **1348**. For instance, if the item is shown as being moved downward towards the interior of the mobile apparatus **102**, and the user’s hand then leaves the basket without the item, it can be determined that the user added the item to the mobile apparatus **102**. Similarly, if the user’s hand moves into the cart without an item, and is depicted in the image data **1348** taking an item from the cart, the event-determination component **1362** may determine that the user removed an item from the mobile apparatus **102**.

The cart management system **1336** may also include a virtual-cart management component **1366** configured to manage virtual shopping cart data **1368** for the mobile apparatus **102**. For instance, the virtual-cart management component **1366** may utilize the item data **1354**, event-description data **1364**, and confidence level data **1356** to add item identifier(s) **1358** to the virtual shopping cart data **1368**

for items that were added to the mobile apparatus **102**, remove item identifier(s) **1358** from the virtual shopping cart data **1368** for items that were removed from the mobile apparatus **102**, and track item quantity data **1370** indicating quantities of particular items in the mobile apparatus **102**.

The cart management system **1336** may further include a user-interface component **1372** configured to present user interfaces on the display **226** based on user-interface data **1374**. The user interfaces may include one or more fields to present data, and/or receive touch input (or other input via a keyboard, mouse, etc.) from a user. For instance, if the item-identification component **1350** is unable to determine an item identifier **1358** for an item shown in the image data **1348**, the user-interface component **1372** may receive inquiry data **1376** generated by an inquiry component **1378** to prompt a user for feedback to help identify the item, and/or other information (e.g., if multiple items were placed in the mobile apparatus **102**). The inquiry component **1378** may be configured to generate inquiry data **1376** based on the information needed to identify the item. For instance, the inquiry data **1376** may include a prompt to request particular feedback from the user, such as to provide input (e.g., touch input, vocal/utterance input, etc.) to identify the item, input to indicate how many items were added to the mobile apparatus **102**, input to indicate whether an item was removed or added, etc. In some examples, the user-interface component **1372** may present one or more images depicting items from the item data **1354** that have the highest confidence levels as corresponding to the item **126** in the image data **1348**, but confidence levels that are not high enough to make a final decision as to the item. For instance, the user-interface component **1372** may present pictures of two different items that have high confidence levels and request that the user select or indicate the appropriate item. Additionally, or alternatively, the user-interface component **1372** may present user-interface data **1374** that prompts the user for feedback regarding whether or not the item was added to, or removed from the mobile apparatus **102**. The user-interface component **1372** may then receive response data **1380** representing a selection of an item.

In some examples, the cart management system **1336** may further include a locating component **1382** configured to determine locations of the mobile apparatus **102** in the facility. For instance, the locating component **1382** may analyze sensor data **1344** collected by sensors of the mobile apparatus **102** to determine a location. In some examples, the communication interface(s) **1306** may include network interfaces that configured the mobile apparatus **102** to receive or detect wireless signals (e.g., WiFi signals, Bluetooth signals, etc.) and generate sensor data **1344** indicative of the signals. The locating component **1382** may analyze the sensor data **1344** using various techniques to identify the location of the mobile apparatus **102**, such as WiFi triangulation, received signal strength indicators (RSSI), and/or other methods for analyzing wireless signals to determine a location of the mobile apparatus **102**. In some instances, the facility may include various infrared (IR) or near-IR emitters at different locations that emit light according to frequencies, patterns, etc. that indicate the different locations in the facility. In such examples, the mobile apparatus **102** may include a light sensor to generate the sensor data **1344** representing the IR or NIR and determine the location of the mobile apparatus **102** in the facility. In some instances, there may be visible landmarks or markers throughout the facility that indicate a location in the facility, and the locating component **1382** may analyze image data **1348** generated by an outward facing camera **1312** to determine a location of

the mobile apparatus 102. As another example, there may be various radio frequency (RF) emitters positioned throughout the store, and the mobile apparatus 102 may include an RF receiver to allow the locating component 1382 to perform IR beaconing to determine the location of the mobile apparatus 102. The locating component 1382 may perform one, or any combination, of the above techniques to determine a location of the mobile apparatus 102 in the facility and/or any other technique known in the art.

The locating component 1382 may perform various operations based on determining the location of the mobile apparatus 102 within the facility. For instance, the locating component 1382 may cause user-interface data 1374 to be presented on the display 226 that includes a map of the facility and/or directions to an item for the user of the mobile apparatus 102. Additionally, or alternatively, the locating component 1382 may utilize the location of the cart, the physical-layout data 1360, and/or item data 1354 and “push” user interfaces to the display 226 that indicate various location-based information, such as indications of deals for items located nearby, indications of items located nearby and on the user’s shopping list, and/or other user-interface data 1374.

As further illustrated in the example of FIG. 13, the mobile apparatus 102 may include a weight component 1384 that is configured to determine weight(s) of item(s) located within the basket 110, located within the shelf 124, and/or located on the tray 140. For a first example, the weight component 1384 may receive sensor data 1344 generated by sensor(s) 1328, where the sensor(s) 1328 include the loadcell(s) of the weight sensor associated with the basket 110. The weight component 1384 may then be configured to analyze the sensor data 1344 in order to determine a weight associated with the basket 110 (and/or the shelf 124). For example, the weight component 1384 may be configured to analyze the sensor data 1344 in order to determine the respective weight measured by each of the loadcell(s). When the weight sensor includes more than one loadcell, the weight component 1384 may then be configured to determine the weight associated with the basket 110 (and/or the shelf 124) using the determined weights. For example, the weight sensor may determine the weight associated with the basket 110 (and/or the shelf 124) by adding each of the determined weights together.

For a second example, the weight component 1384 may receive sensor data 1344 generated by sensor(s) 1328, where the sensor(s) 1328 include the loadcell(s) of the weight sensor associated with the tray 140. The weight component 1384 may then be configured to analyze the sensor data 1344 in order to determine a weight associated with the tray. For example, the weight component 1384 may be configured to analyze the sensor data 1344 in order to determine the respective weight measured by each of the loadcell(s). Again, when the weight sensor includes more than one loadcell, the weight component 1384 may then be configured to determine the weight associated with the tray 140 using the determined weights. For example, the weight sensor may determine the weight associated with the tray 140 by adding each of the determined weights together.

The weight component 1384 may use these weights to determine the weight of the item placed within the basket 110, located within the shelf 124, and/or located on the tray 140. For example, the weight component 1384 may perform the processes above in order to determine a first weight associated with the basket 110 (and/or the shelf 124) at a first time. The weight component 1384 may then perform the processes above in order to determine a second weight

associated with the basket 110 (and/or the shelf 124) at a second, later time. In some examples, the weight component 1384 receives the sensor data 1344 and/or determines the weights at the elapse of given time periods (e.g., every second, two seconds, five seconds, etc.). In some examples, the weight component 1384 receives the sensor data 1344 and/or determines the weights based on detecting that an item has been placed within the basket 110 (and/or the shelf 124), such as based on the output from the activity-detection component 1342, the item-identification component 1350, and/or the event-determination component 1362. In either example, the weight component 1384 may use the first weight and the second weight to determine the weight of the item.

For example, the weight component 1384 may determine whether the second weight is greater than the first weight. If the weight component 1384 determines that the second weight substantially equal to the first weight, then the weight component 1384 may determine that a new item has not been placed within the basket 110 (and/or the shelf 124). However, if the weight component 1384 determines that the second weight greater than the first weight, then the weight component 1384 may determine that a new item has been placed within the basket 110 (and/or the shelf 124). In some examples, the weight component 1384 may then determine the weight of the item using the weights, such as by taking the difference between the second weight and the first weight.

Additionally, or alternatively, in some examples, the weight component 1384 may use the first weight and the second weight to determine that an item has been removed from the basket 110 (and/or the shelf 124). For example, the weight component 1384 may determine that the second weight is less than the first weight. Based on the determination, the weight component 1384 may determine that an item has been removed from the basket 110 (and/or the shelf 124). In some examples, the weight component 1384 may then determine the weight of the item using the weights, such as by taking the difference between the first weight and the second weight. Additionally, if the mobile apparatus 102 already knows the weights of each of the items, the mobile apparatus 102 may determine which item was removed by matching the weight of the item removed to the weight of one of the items within the basket 110 (and/or the shelf 124).

While the examples above describe determining the weights of items placed within and/or removed from the basket 110 (and/or the shelf 124), in other examples, the weight component 1384 may perform similar processes to determine the weights of items placed on the tray 140.

In some examples, the virtual-cart management component 1306 may be configured to generate item weight data 1386 representing the weight of the items, which the virtual-cart management component 1306 may store as part of the virtual shopping cart data 1368. Additionally, in some examples, the item data 1354 may represent the price per unit weight of certain items within the facility. In such examples, the virtual-cart management component 1366 may be configured to use the item weight data 1386 and the item data 1354 in order to determine the price of such an item that is placed within the basket 110, the shelf 124, and/or on the tray 140. The mobile apparatus 102 may then be configured to provide the price of the item to the user, such as using the display 132.

FIG. 14 is a block diagram 1400 of an example materials handling facility 1402 (also referred to the “facility 1402”) that includes carts and an item management system configured to generate output regarding events occurring in the



cart using sensor data. However, the following description is merely one illustrative example of an industry and environment in which the techniques described herein may be utilized.

An example of the facility **1402** configured to store and manage inventory items is illustrated in FIG. **14**. The facility **1402** comprises one or more physical structures or areas within which one or more items **1404(1)**, **1404(2)**, . . . , **1404(Q)** (generally denoted as **1404**) may be held. As used in this disclosure, letters in parenthesis such as “(Q)” indicate an integer result. The items **1404** comprise physical goods, such as books, pharmaceuticals, repair parts, electronic gear, groceries, and so forth.

The facility **1402** may include one or more areas designated for different functions with regard to inventory handling. In this illustration, the facility **1402** includes a receiving area **1406**, a storage area **1408**, and a transition area **1410**. The receiving area **1406** may be configured to accept items **1404**, such as from suppliers, for intake into the facility **1402**. For example, the receiving area **1406** may include a loading dock at which trucks or other freight conveyances unload the items **1404**.

The storage area **1408** is configured to store the items **1404**. The storage area **1408** may be arranged in various physical configurations. In one example, the storage area **1408** may include one or more aisles **1412**. The aisles **1412** may be configured with, or defined by, inventory locations **1414** on one or both sides of the aisle **1412**. The inventory locations **1414** may include one or more of shelves, racks, cases, cabinets, bins, floor locations, or other suitable storage mechanisms for holding or storing the items **1404**. The inventory locations **1414** may be affixed to the floor or another portion of the facility’s structure, or may be movable such that the arrangements of aisles **1412** may be reconfigurable. In some examples, the inventory locations **1414** may be configured to move independently of an outside operator. For example, the inventory locations **1414** may comprise a rack with a power source and a motor, operable by a computing device to allow the rack to move from one location within the facility **1402** to another.

One or more users **1416(1)**, . . . , **1416(U)**, carts **1418(1)**, . . . , **1418(T)** (generally denoted as **1418**) or other material handling apparatus may move within the facility **1402**. For example, the users **1416** may move about within the facility **1402** to pick or place the items **1404** in various inventory locations **1414**, placing them on the carts **1418** for ease of transport. An individual cart **1418** is configured to carry or otherwise transport one or more items **1404**. For example, a cart **1418** may include a basket, a cart, a bag, and so forth. In other examples, other agencies such as robots, forklifts, cranes, aerial drones, and so forth, may move about the facility **1402** picking, placing, or otherwise moving the items **1404**.

One or more sensors may be configured to acquire information in the facility **1402**. The sensors in the facility **1402** may include sensors fixed in the environment (e.g., ceiling-mounted cameras) or otherwise, such as sensors in the possession of users (e.g., mobile phones, tablets, etc.) or sensors mounted on the carts **1418**. The sensors may include, but are not limited to, cameras, weight sensors (e.g., in the bottom of the carts **1418**), radio frequency (RF) receivers, temperature sensors, humidity sensors, vibration sensors, and so forth. The sensors may be, in some examples, in or on the cart **1418** or another location in the facility **1402**. In one example, the bottom of a basket of the carts **1418** may include weight sensors configured to determine a weight of the items **1404** placed thereupon.

During operation of the facility **1402**, the sensors may be configured to provide information suitable for identifying the movement of items **1404** or other occurrences within the cart **1418**. For example, a series of images acquired by a camera may indicate removal of an item **1404** from a particular cart **1418** by one of the users **1416** and/or placement of the item **1404** on or at least partially within one of the carts **1418**.

While the storage area **1408** is depicted as having one or more aisles **1412**, inventory locations **1414** storing the items **1404**, sensors, and so forth, it is understood that the receiving area **1406**, the transition area **1410**, or other areas of the facility **1402** may be similarly equipped. Furthermore, the arrangement of the various areas within the facility **1402** is depicted functionally rather than schematically. For example, multiple different receiving areas **1406**, storage areas **1408**, and transition areas **1410** may be interspersed rather than segregated in the facility **1402**.

The carts **1418** and/or the inventory location **1414** may include, or be coupled to, an item management system **1420**. The item management system **1420** is configured to identify interactions with and between users **1416**, carts **1418**, and/or the inventory location **1414**, in one or more of the receiving area **1406**, the storage area **1408**, or the transition area **1410**. These interactions may include one or more events **1424**. For example, events **1424** may include placing of an item **1404** in a cart **1418**, returning of an item **1404** from the cart **1418** to an inventory location **1414**, placing an item **1404** on the inventory location **1414**, removing an item **1404** from the inventory location **1414**, and/or any of the other events described herein. Other events **1424** involving users **1416** may include the user **1416** providing authentication information in the facility **1402**, using a computing device at the facility **1402** to authenticate identity to the item management system **1420**, and so forth.

By determining the occurrence of one or more of the events **1424**, the item management system **1420** may generate output data **1422**. The output data **1422** comprises information about the event **1424**. For example, where the event **1424** comprises an item **1404** being removed from, or placed in, a cart **1418**, the output data **1422** may comprise an item identifier indicative of the particular item **1404** that was removed from, or placed in, the cart **1418**, a quantity of the item **1404**, a user identifier of a user that removed the item **1404**, and/or other output data **1422**.

The item management system **1420** may use one or more automated systems to generate the output data **1422**. For example, an artificial neural network, one or more classifiers, or other automated machine learning techniques may be used to process the sensor data and/or image data from the one or more sensors to generate output data **1422**. The automated systems may operate using probabilistic or non-probabilistic techniques. For example, the automated systems may use a Bayesian network. In another example, the automated systems may use support vector machines to generate the output data **1422** or the tentative results. The automated systems may generate confidence level data that provides information indicative of the accuracy or confidence that the output data **1422** or the tentative data corresponds to the physical world.

The confidence level data may be generated using a variety of techniques, based at least in part on the type of automated system in use. For example, a probabilistic system using a Bayesian network may use a probability assigned to the output as the confidence level. Continuing the example, the Bayesian network may indicate that the probability that the item depicted in the image data corre-

sponds to an item previously stored in memory is 145%. This probability may be used as the confidence level for that item as depicted in the image data.

In another example, output from non-probabilistic techniques such as support vector machines may have confidence levels based on a distance in a mathematical space within which the image data of the item and the images of previously stored items have been classified. The greater the distance in this space from a reference point such as the previously stored image to the image data acquired during the occurrence, the lower the confidence level.

In yet another example, the image data of an object such as an item **1404** may be compared with a set of previously stored images. Differences between the image data and the previously stored images may be assessed. For example, differences in shape, color, relative proportions between features in the images, and so forth. The differences may be expressed in terms of distance with a mathematical space. For example, the color of the object as depicted in the image data and the color of the object as depicted in the previously stored images may be represented as coordinates within a color space.

The confidence level may be determined based at least in part on these differences. For example, the user **1416** may pick an item **1404(1)** such as a perfume bottle that is generally cubical in shape from the inventory location **1414**. Other items **1404** at nearby inventory locations **1414** may be predominately spherical. Based on the difference in shape (cube vs. sphere) from the adjacent items, and the correspondence in shape with the previously stored image of the perfume bottle item **1404(1)** (cubical and cubical), the confidence level that the user **1416** has picked up the perfume bottle item **1404(1)** is high.

In some situations, the automated techniques may be unable to generate output data **1422** with a confidence level above a threshold result. For example, the automated techniques may be unable to distinguish which item **1404** in large a group of items a user **1416** has picked up from the inventory location **1414** and placed in the cart **1418**. In other situations, it may be desirable to provide human confirmation of the event **1424** or of the accuracy of the output data **1422**. For example, some items **1404** may be deemed age restricted such that they are to be handled only by users **1416** above a minimum age threshold.

In instances where human confirmation is desired, sensor data associated with an event **1424** may be processed to generate inquiry data. The inquiry data may include a subset of the sensor data associated with the event **1424**. The inquiry data may also include one or more of one or more tentative results as determined by the automated techniques, or supplemental data. The subset of the sensor data may be determined using information about the one or more sensors. The subset of the sensor data may include images that may show the item **1404** being placed in, or removed from, the cart **1418**. The subset of the sensor data may also omit images from other cameras that did not have that item **1404** in the field of view. The field of view may comprise a portion of the scene in the cart **1418** that the camera is able to generate sensor/image data about.

Continuing the example, the subset of the sensor data may comprise a video clip acquired by one or more cameras having a field of view that includes the item **1404**. The tentative results may comprise the “best guess” as to which items **1404** may have been involved in the event **1424**. For example, the tentative results may comprise results determined by the automated system that have a confidence level above a minimum threshold.

The facility **1402** may be configured to receive different kinds of items **1404** from various suppliers and to store them until a customer orders or retrieves one or more of the items **1404**. A general flow of items **1404** through the facility **1402** is indicated by the arrows of FIG. **14**. Specifically, as illustrated in this example, items **1404** may be received from one or more suppliers, such as manufacturers, distributors, wholesalers, and so forth, at the receiving area **1406**. In various examples, the items **1404** may include merchandise, commodities, perishables, or any suitable type of item **1404**, depending on the nature of the enterprise that operates the facility **1402**. The receiving of the items **1404** may comprise one or more events **1424** for which the item management system **1420** may generate output data **1422**.

Upon being received from a supplier at receiving area **1406**, the items **1404** may be prepared for storage. For example, items **1404** may be unpacked or otherwise rearranged. An inventory management system of the facility **1402** may include one or more software applications executing on a computer system to provide inventory management functions based on the events **1424** associated with the unpacking or rearrangement. These inventory management functions may include maintaining information indicative of the type, quantity, condition, cost, location, weight, or any other suitable parameters with respect to the items **1404**. The items **1404** may be stocked, managed, or dispensed in terms of countable, individual units or multiples, such as packages, cartons, crates, pallets, or other suitable aggregations. Alternatively, some items **1404**, such as bulk products, commodities, and so forth, may be stored in continuous or arbitrarily divisible amounts that may not be inherently organized into countable units. Such items **1404** may be managed in terms of measurable quantity such as units of length, area, volume, weight, time, duration, or other dimensional properties characterized by units of measurement. Generally speaking, a quantity of an item **1404** may refer to either a countable number of individual or aggregate units of an item **1404** or a measurable amount of an item **1404**, as appropriate.

After arriving through the receiving area **1406**, items **1404** may be stored within the storage area **1408**. In some examples, like items **1404** may be stored or displayed together in the inventory locations **1414** such as in bins, on shelves, hanging from pegboards, and so forth. In this example, all items **1404** of a given kind are stored in one inventory location **1414**. In other examples, like items **1404** may be stored in different inventory locations **1414**. For example, to optimize retrieval of certain items **1404** having frequent turnover within a large physical facility **1402**, those items **1404** may be stored in several different inventory locations **1414** to reduce congestion that might occur at a single inventory location **1414**.

When a customer order specifying one or more items **1404** is received, or as a user **1416** progresses through the facility **1402**, the corresponding items **1404** may be selected or “picked” from the inventory locations **1414** containing those items **1404**. In various examples, item picking may range from manual to completely automated picking. For example, in one example, a user **1416** may have a list of items **1404** they desire and may progress through the facility **1402** picking items **1404** from inventory locations **1414** within the storage area **1408**, and placing those items **1404** into a cart **1418**. In other examples, employees of the facility **1402** may pick items **1404** using written or electronic pick lists derived from customer orders. These picked items **1404** may be placed into the cart **1418** as the employee progresses through the facility **1402**. Picking may comprise one or more events **1424**, such as the user **1416** in moving to the

inventory location **1414**, retrieval of the item **1404** from the inventory location **1414**, and so forth.

After items **1404** have been picked, they may be processed at a transition area **1410**. The transition area **1410** may be any designated area within the facility **1402** where items **1404** are transitioned from one location to another or from one entity to another. For example, the transition area **1410** may be a packing station within the facility **1402**. When the item **1404** arrives at the transition area **1410**, the items **1404** may be transitioned from the storage area **1408** to the packing station. Information about the transition may be maintained by the item management system **1420** using the output data **1422** associated with those events **1424**.

In another example, if the items **1404** are departing the facility **1402** a list of the items **1404** may be used by the item management system **1420** to transition responsibility for, or custody of, the items **1404** from the facility **1402** to another entity. For example, a carrier may accept the items **1404** for transport with that carrier accepting responsibility for the items **1404** indicated in the list. In another example, a customer may purchase or rent the items **1404** and remove the items **1404** from the facility **1402**.

The item management system **1420** may access or generate sensor data about the items **1404**, the users **1416**, the carts **1418**, and so forth. The sensor data may be acquired by one or more of the sensors, data provided by other systems, and so forth. For example, the sensors may include cameras configured to acquire image data of items **1404** placed in the carts **1418**. The image data may comprise still images, video, or a combination thereof. The image data may be processed by the item management system **1420** to determine an item identifier for the items **1404**, a listing of items in the cart **1418** for a user **1416**, and so forth. As used herein, the identity of the user of a cart **1418** may represent a unique identifier of the user (e.g., name, number associated with user, username, etc.), an identifier that distinguishes the user amongst other users being identified with the environment, or the like.

The item management system **1420**, or systems coupled thereto, may be configured to identify the user **1416**. In one example, this determination may comprise comparing sensor data with previously stored identity data. For example, the user **1416** may be identified by showing their face to a facial recognition system, by presenting a token carrying authentication credentials, providing a fingerprint, scanning a barcode or other type of unique identifier upon entering the facility, and so forth. Identity of the user **1416** may be determined before, during, or after entry to the facility **1402** and/or interaction with a cart **1418**. Determination of the user's **1416** identity may comprise comparing sensor data associated with the user **1416** in the facility **1402** and/or with the cart **1418** to previously stored user data. In some examples, the output data **1422** may be transmitted over a network **1426** to server(s) **1428**.

Separate instances of these programs can be executed on or distributed across any number of separate computer systems. Thus, although certain steps have been described as being performed by certain devices, software programs, processes, or entities, this need not be the case, and a variety of alternative examples will be understood by those having ordinary skill in the art.

Additionally, those having ordinary skill in the art readily recognize that the techniques described above can be utilized in a variety of devices, environments, and situations. Although the subject matter has been described in language specific to structural features or methodological acts, it is to be understood that the subject matter defined in the

appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as exemplary forms of implementing the claims.

While the foregoing invention is described with respect to the specific examples, it is to be understood that the scope of the invention is not limited to these specific examples. Since other modifications and changes varied to fit particular operating requirements and environments will be apparent to those skilled in the art, the invention is not considered limited to the example chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

What is claimed is:

**1.** A shopping cart comprising:

- an upper frame;
- a basket comprising:
  - a first bottom having a first perimeter;
  - three sides coupled to and extending upward from the first bottom; and
  - a gate extending substantially downward from a first side of the three sides and a second side of the three sides, wherein the first bottom, the three sides, and the gate at least partly define an interior cavity of the basket to hold at least a first item;
- a chassis coupled to the upper frame;
- a first expansion joint that attaches a first portion of the chassis to a front-left portion of the first bottom of the basket;
- a second expansion joint that attaches a second portion of the chassis to a front-right portion of the first bottom of the basket;
- a third expansion joint that attaches a third portion of the chassis to a back-left portion of the first bottom of the basket;
- a fourth expansion joint that attaches a fourth portion of the chassis to a back-right portion of the first bottom of the basket;
- one or more weight sensors, the one or more weight sensors disposed between the chassis and the basket;
- a shelf coupled to and extending substantially horizontally from a back-portion of the first bottom of the basket, the shelf comprising:
  - a second bottom having a second perimeter; and
  - four sides coupled to and extending upward from the second perimeter, wherein the second bottom and the four sides define an interior cavity of the shelf to hold at least a second item;
- a substantially vertical member extending substantially downward from the upper frame and to a top of a wheel frame; and
- wheel castors coupled to a bottom of the wheel frame.

**2.** The shopping cart as recited in claim **1**, further comprising:

- a handlebar module coupled to the upper frame, the handlebar module comprising:
  - an opening; and
  - a first rail feature disposed at least partially within the opening; and
- a battery that is removable from the opening, the battery comprising a second rail feature that is configured to engage with the first rail feature in order to guide the battery into the opening.

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3. The shopping cart as recited in claim 1, wherein the chassis further comprises:

an opening; and

a screw that connects the chassis to the basket through the opening, the screw to maintain an alignment of the basket in order to prevent the basket from contacting the upper frame.

4. A mobile apparatus comprising:

an upper frame;

a basket comprising:

a first bottom having a first perimeter;

three sides coupled to and extending upward from the bottom; and

a gate extending substantially downward from a first side of the three sides and a second side of the three sides, the gate including a component that prevents the gate from contacting the upper frame, and wherein the first bottom, the three sides, and the gate define a first receptacle of the basket;

a shelf coupled to and extending from the basket, the shelf comprising:

a second bottom having a second perimeter; and

four sides coupled to and extending upward from the second bottom, the second bottom and the four sides defining a second receptacle of the shelf;

a chassis coupled to the upper frame;

a fastener that attach the basket to the chassis;

one or more weight sensors disposed between the chassis and the basket;

a vertical member extending substantially downward from the upper frame and to a wheel frame; and

one or more wheel castors coupled to the wheel frame.

5. The mobile apparatus as recited in claim 4, wherein: the chassis includes an opening; and

the fastener is located at least partially within the opening, the fastener to align the basket onto the chassis in order to prevent the basket from contacting the upper frame.

6. The mobile apparatus as recited in claim 4, the fastener comprises an expansion joint that attach the chassis to the basket.

7. The mobile apparatus as recited in claim 4, wherein the upper frame further comprises one or more openings, and wherein the mobile apparatus further comprises:

a handlebar module coupled to the upper frame; and

an electrical connector disposed through the one or more openings, the electrical connector to attach the one or more weight sensors to the handlebar module.

8. The mobile apparatus as recited in claim 4, wherein the one or more weight sensors comprise at least:

a first loadcell disposed between a first portion of the basket and a first portion of the chassis; and

a second loadcell disposed between a second portion of the basket and a second portion of the chassis.

9. The mobile apparatus as recited in claim 4, wherein:

the bottom of the basket includes a groove; and

the gate is configured to move between a first position and a second position, the component of the gate configured to insert into the groove when the gate is in the first position in order to secure the gate to the bottom of the basket.

10. The mobile apparatus as recited in claim 4, wherein the bottom of the basket includes at least one spacer, the at least one spacer marking a separation of a first portion of the basket from a second portion of the basket.

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11. The mobile apparatus as recited in claim 4, further comprising:

a handlebar module coupled to the upper frame, the handlebar module comprising an opening; and

a removable battery that is disposed within the opening.

12. The mobile apparatus as recited in claim 11, wherein: the opening further comprises a first rail feature; and the removable battery comprises a second rail feature that is configured to engage with the first rail feature in order to guide the battery into the opening.

13. The mobile apparatus as recited in claim 11, wherein: the opening is a first opening

the handlebar module further comprises:

a prong that is configured to move between a first position and a second position, the prong to secure the removable battery within the first opening when in the first position; and

a second opening; and

the mobile apparatus further comprises a key that is configured to insert into the second opening in order to cause the prong to move to the second position.

14. The mobile apparatus as recited in claim 4, further comprising:

a handlebar module coupled to the upper frame, the handlebar module comprising at least:

a display; and

an imaging device; and

a bar coupled to a first side of the upper frame and a second side of the upper frame, the bar to protect the handlebar module.

15. The mobile apparatus as recited in claim 4, further comprising:

one or more imaging devices;

one or more processors; and

one or more computer-readable media storing instructions that, when executed by the one or more processors, cause the one or more processors to perform operations comprising:

receiving sensor data from the one or more weight sensors;

determining a weight of an item based at least in part on the first sensor data;

receiving image data from the one or more imaging devices;

determining that the image data represents an identifier associated with an item; and

generating item data representing at least:

the identifier associated with the item; and

the weight of the item.

16. A mobile apparatus comprising:

an upper frame;

a chassis coupled to the upper frame;

a basket disposed on the chassis, the basket comprising:

a bottom having a perimeter; and

one or more sides coupled to and extending upward from the bottom, the bottom and the one or more sides defining a receptacle;

a handlebar module coupled to the upper frame, the handlebar module comprising an opening;

a removable battery that is disposed within the opening, the removable battery comprising a cavity, and wherein the opening comprises a prong that is configured to move between a first position and a second position, the prong disposed within the cavity when in the first position in order to secure the removable battery within the opening;

one or more sensors;

a vertical member extending downward from the upper frame and to a wheel frame; and

one or more wheel castors coupled to the wheel frame.

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17. The mobile apparatus as recited in claim 16, wherein:  
the opening further comprises a first rail feature; and  
the removable battery comprises a second rail feature, the  
first rail feature and the second rail feature configured  
to guide the battery into the opening.

18. The mobile apparatus as recited in claim 16, further  
comprising one or more fasteners that attach the basket to  
the chassis in order to prevent the basket from contacting the  
upper frame.

19. The mobile apparatus as recited in claim 4, further  
comprising:

a handlebar module coupled to the upper frame, the  
handlebar module comprising an opening; and

a removable battery that is disposed within the opening,  
the removable battery comprising a cavity, and wherein  
the opening comprises a prong that is configured to  
move between a first position and a second position, the  
prong disposed within the cavity when in the first  
position in order to secure the removable battery within  
the opening.

20. The mobile apparatus as recited in claim 16, wherein:  
the bottom is a first bottom;  
the perimeter is a first perimeter;  
the first bottom and the one or more sides define a first  
receptacle of the basket; and

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the mobile apparatus further comprises a shelf coupled to  
and extending from the basket, the shelf comprising:  
a second bottom having a second perimeter; and  
four sides coupled to and extending upward from the  
second bottom, the second bottom and the four sides  
defining a second receptacle of the shelf.

21. A mobile apparatus comprising:

an upper frame;

a basket comprising:

a first bottom having a first perimeter;

three sides coupled to and extending upward from the  
bottom; and

a gate extending substantially downward from an upper  
edge of the basket, the gate including a component that  
prevents the gate from contacting the upper frame;

a shelf coupled to and extending from the basket, the shelf  
comprising:

a second bottom having a second perimeter; and

four sides coupled to and extending upward from the  
second bottom;

a chassis coupled to the upper frame, wherein the basket  
is coupled to the chassis;

one or more weight sensors disposed between the chassis  
and the basket;

a vertical member extending substantially downward  
from the upper frame and to a wheel frame; and

one or more wheel castors coupled to the wheel frame.

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